Building a Community of Scholars: One University's Story of Students Engaged in Learning Science, Mathematics, and Engineering Through a NSF S-STEM Grant

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Abstract

The School of Engineering, Mathematics, and Science (SEMS) at Robert Morris University (RMU) was awarded a five-year grant from the National Science Foundation (NSF) to fund scholarships to 21 academically talented but financially challenged students majoring in the disciplines of science, technology, engineering, and mathematics (STEM). Each student will receive a total of $24,000 over their four years of study. This study presents the planning of the first cohort and its experiences during the first year of the grant project. Most importantly, this paper focuses on the experiences and tracking data from these students during their first year as college students.

Terms: STEM (Science, Technology, Engineering, and Mathematics), SEMS (School of Engineering, Math and Science), FASFA (Free Application for Federal Student Aid), PELL Grant (The Federal Pell Grant Program provides need-based grants to low-income undergraduate and certain post-baccalaureate students to promote access to postsecondary education)

Introduction

While 25 percent of high-achieving lower-income students fall out of the top academic quartile in math in high school, only 16 percent of high-achieving upper income students do so (Learning Matters, Inc., 2010). This margin of difference may affect how these same lower-income students perceive math and science programs. There is also evidence that math and science are yet among the subjects under-represented by minorities and women. Not only are they limited in terms of income, but they may also be limited as to the choice of discipline or major, especially in the math and science areas. With this in mind, The School of Engineering, Mathematics, and Science (SEMS) at Robert Morris University successfully pursued a five-year grant from the National Science Foundation (NSF) to award scholarships to 21 academically talented, but financially challenged students majoring in the disciplines of science, technology, engineering, and mathematics (STEM). The purpose of this paper is to report the findings from the first year of the STEM program relative to both academic progress and self-efficacy of the student participants.

Background

In a report from Tapping America's Promise: Education for Innovation Initiative 2008, it was noted that by the year 2015, the goal was to increase the annual number of U.S. science, technology, engineering, and math bachelor level undergraduates. The competition from foreign countries certainly has impacted the United States relative to its ability to move forward in these key areas. In fact, President Obama (2010) proposed a national initiative to increase the number of mathematics and science teachers across the nation, and recognized more than 100 educators and mentors, including 56 NEA members, for their outstanding contributions to science, technology, engineering, and mathematics (STEM). In the president's fiscal year 2011 budget, $150 million of the Investing in Innovation fund will be focused on STEM projects. Moving forward is not a matter of suggestion, but rather a matter of expressed need.

To meet this need, Robert Morris University successfully embarked on a grant-seeking opportunity through the National Science Foundation. After weighing and considering various options, it was decided that the School of Engineering, Mathematics and Science (SEMS) at Robert Morris University would target a group of local students who were academically talented, but financially challenged, to participate in a college program with emphasis on the disciplines of science, technology, engineering, and mathematics. A total of 21 students were identified with the assistance of the admissions counselors here at the University. The STEM grant would cover a five-year period and provide each student with a stipend of $24,000 for expenses during the four-year period while pursuing their degree.

Project Planning Year 2008-2009

The RMU Admissions Office and the Management Team first identified potential students for the STEM scholarship by evaluating the students admitted to RMU in the STEM majors who met the academic criteria for the scholarship. The students who met the PELL Grant requirement through the FAFSA loan program and met the academic and other requirements were selected through a phone interview process to receive the STEM scholarship.

During the planning year of the project, the SEMS Management Team completed preparation for the arrival of the Living-Learning Cohort of the STEM Scholars. The team worked closely with several departments at the University, including Admissions, Institutional Research, Financial Aid, the Registrar's Office, Student Affairs, Career Services, Residence Life, and more. The team had more than 20 planning meetings during the year in order to recruit and successfully prepare for the arrival of the students. As a result of successful recruitment efforts, the cohort initially consisted of 21 students majoring in STEM disciplines at Robert Morris University (seven in each discipline of science, engineering, and mathematics). The majority of these students (13 out of the 21 students in the applicant pool, or 62 percent) are first-generation college attendees, and 11 (52 percent) are female.

The Student Services and Residential Life Offices helped identify living arrangements for the cohort. The cohort resided on the 4th Floor of Washington Hall, a newly renovated dormitory on campus. The cohort has a designated Resident Assistant who was a sophomore at RMU and majoring in Environmental Science, Biology Teacher Certification. The students' living arrangements included: a room shared by two students of the same gender from the cohort, a study area, a meeting area, showers, a laundry room in the building, and other amenities.

The Management Team organized the Mathematics and Science Boot Camp (MSBC). The main goal of the MSBC was to prepare and give the students the advantage in their future science and mathematics classes and to form camaraderie in the new Living-Learning Cohort of these STEM Scholars. At RMU all incoming freshmen, including the STEM Scholars, have to take a mathematics placement test during the spring or summer before the start of the fall semester. The MSBC also took placement tests as a precursor to boot camp. Based on these placement test results, students in the cohort refreshed main aspects of mathematics, learned about technology in mathematics classes, and generated communicable, written solutions to math problems. The physics and chemistry workshops of the MSBC also started with pre-tests to evaluate the students' level of preparation. Students arrived on campus two weeks before the start of the semester, which was Aug. 24, 2009, not only to participate in academic exercises but also in service activities, and they also worked among others on their communication and personal skills.

The two-week program began on August 9 with an introductory dinner and ran until Aug. 20, 2009. During the Software Engineering activity, the IT department at Robert Morris University supplied an iPod Touch to each student with the intention that they might author user friendly applications that can be used by the entire university. To date, there have not been any applications created. During the second week, students were involved in orientation sessions that included community service, cultural activities, reading and writing skills strategies, as well as success, note taking, time management, critical thinking, and decision making skills. They also learned more about the university as a community, which included academic services, career services, engagement transcripts, financial aid, the library, cultural diversity, and more. The week was followed by a separate Freshmen Orientation presented by Student Services.

In the ensuing weeks, students were given surveys before and after the MSBC to evaluate their learning progress and social cohesiveness. Another survey was administered at the end of their freshman year. The surveys were approved during the planning year by the Robert Morris University Institutional Review Board (IRB) for future publication of the data. The Management Team then worked with Academic Services and the Registrars Office to determine what common courses in science, mathematics, communication skills and core courses the STEM Scholars would take for their freshman year. The intention was to schedule the group for the same class sections.

The Living-Learning Cohort was also planned to be involved in other academic and professional experiences, including meeting with professionals, sharing their internships, co-ops, and research experiences with the cohort and other students in SEMS programs. They have already been involved in several community service projects, totaling over 300 hours, including "Habitat for Humanity" in a nearby town where the entire cohort was present. The non-profit partners selected and the volunteer work in which the students are engaged, may or may not make direct use of the STEM course concepts they are learning in the classroom. This is being left to the students to determine. In either case, students will have the opportunity to develop their civic identity through service, reflection, and leadership opportunities. They also experienced a cultural activity when they visited "Fallingwater." Fallingwater is a National Historic Landmark located in southwestern Pennsylvania and is considered to be one of the greatest architectural designs in America. The members will also be involved in other outreach activities throughout their undergraduate careers. This cohort will be a strong support mechanism to help other students to adapt to the college environment and succeed in the future.

STEM Scholars' Freshman Year Performance

Out of the original 21 students of the STEM Cohort, only two transferred to other universities at the end of the fall semester and one left Robert Morris University about two-thirds into the spring semester because of disciplinary reasons. After the end of the spring semester, the Management team was informed that the one alternate was no longer PELL and scholarship eligible and another student will not return because of medical reasons. This gave us a retention rate of about 81 percent (17 out of the original 21) for the first year. The PELL ineligible student will remain at RMU, but cannot be in the cohort.

When looking at the retention rates of all STEM students at Robert Morris University from the last two years, 2007-2008 and 2008-2009 (Figure 1), there was no change in the total number of students (both years were 78 percent). However, there was an 18 percent increase in the retention of Engineering students and an 8 percent decrease in both the mathematics and science students.

When comparing the STEM Cohort to previous numbers, the overall retention rate is 81 percent which is 3 percent greater. In each discipline of the cohort, engineering has a 100 percent retention rate, mathematics 86 percent, and science 57 percent. In all areas, the retention rate of the STEM Cohort is better than the retention rate for all STEM students, except in science, where the retention rate was much higher at 84 percent.

The cohort as a group did very well academically for their first year (Figure 2 and Table 1). The overall QPA, 3.29, is equivalent to a B+. For the Fall 2009 semester, fourteen students had GPAs that ranged from 3.43 to 4.00 which is 67 percent. The remaining seven students had GPAs below 3.00: four students ranged from 2.62 to 2.84 and the other three were from 2.00 to 2.33. For the Spring 2010 semester, thirteen students had GPAs that ranged from 3.05 to 4.00 which is 62 percent, four students ranged from 2.78 to 2.98, and the other four students had a 2.34 and below.

It can be also noted from Table 1 that the overall GPA average for all STEM participants was 3.29, with mathematics students having a GPA average of 3.45, engineering students having a GPA average of 3.22 and science students having a GPA average of 3.17. Using a GPA of 3.0 as a measure for a year-end success, we note however that while 100 percent of the Mathematics students achieved this criterion, only 50 percent of the Engineering students and 60 percent of the science students achieved this goal. It is noted that three stu-

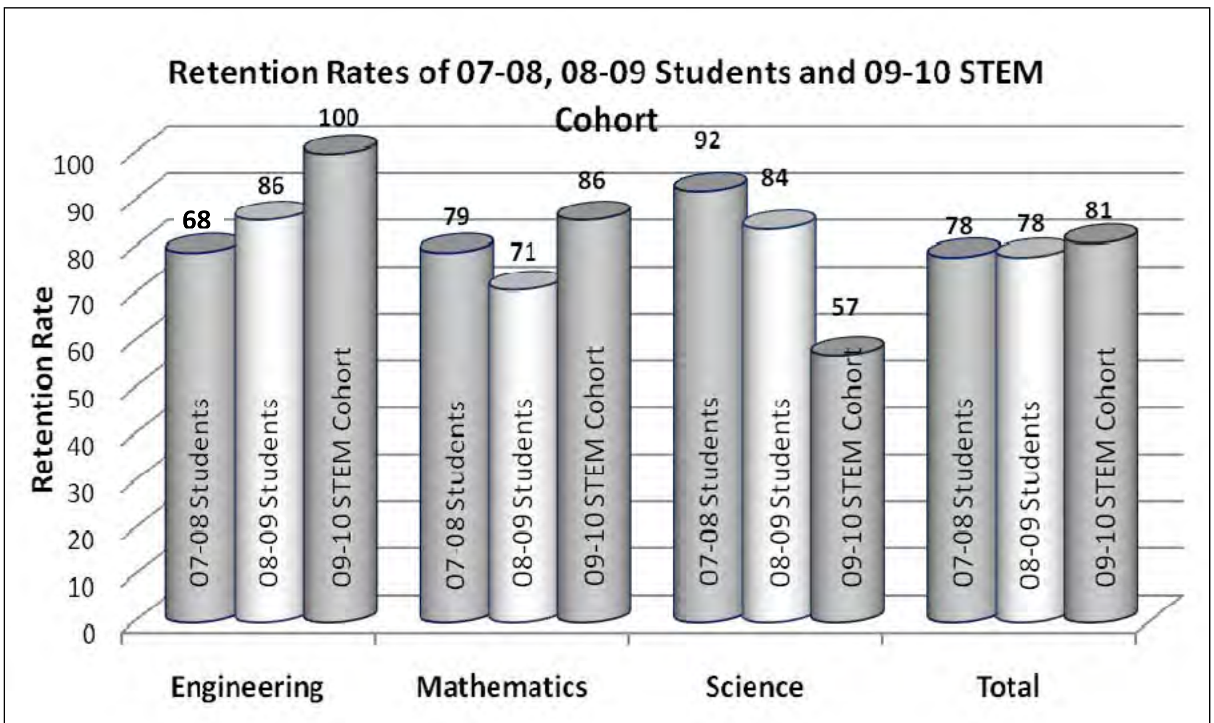

Figure 1. Retention Rate of 07-08, 08-09 Students and 09-10 STEM Cohort

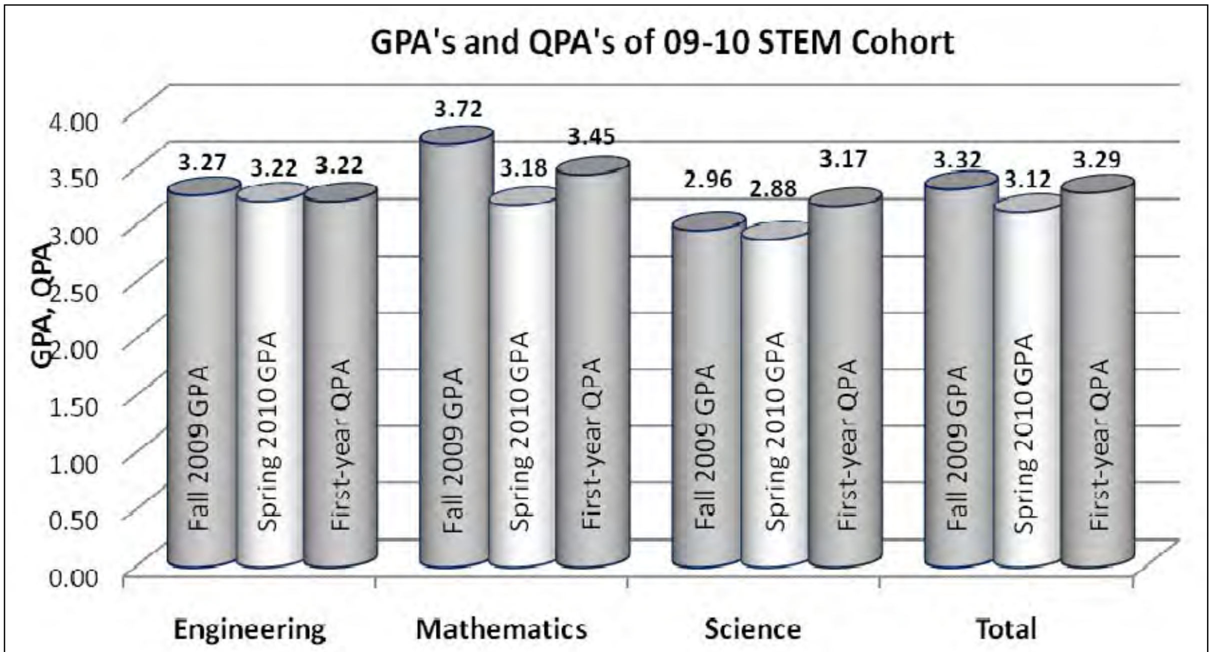

Figure 2. GPA's and QPA's of 09-10 STEM Cohort

DISCIPLINE	MAJOR	FALL 2009 GPA	SPRING 2010 GPA	FIRST YEAR QPA
Engineering	Engineering – Mechanical	2.72	2.78	2.75
Engineering	Engineering – Mechanical	3.71	3.82	3.76
Engineering	Engineering – Mechanical	3.43	3.77	3.60
Engineering	Engineering – Software*	---	2.93	2.90
Engineering	Engineering – Mechanical	2.82	2.34	2.60
Engineering	Engineering – Mechanical	2.62	3.29	2.85
Engineering	Engineering – Biomedical	3.72	3.81	3.76
Engineering	Engineering – Biomedical	3.87	3.05	3.51
GPA Average Engineering		**3.27**	**3.22**	**3.22**
Math	Actuarial Science	3.88	2.85	3.42
Math	Actuarial Science	3.63	3.23	3.44
Math	Actuarial Science	3.82	3.19	3.52
Math	Actuarial Science**	3.82	---	---
Math	Applied Mathematics	3.65	2.98	3.31
Math	Applied Mathematics - Math Education	3.50	3.19	3.34
Math	Actuarial Science*	---	3.59	3.60
Math	Actuarial Science	3.75	3.25	3.54
GPA Average Mathematics		**3.72**	**3.18**	**3.45**
Science	Biology - Pre-Medicine	4.00	4.00	4.00
Science	Biology - Pre-Medicine	3.95	3.95	3.95
Science	Biology - Pre-Medicine	3.62	3.80	3.70
Science	Biology**	2.00	---	---
Science	Environmental Science***	2.00	---	---
Science	Biology	2.33	2.12	2.23
Science	Biology - Pre-Medicine	2.84	0.53	1.95
GPA Average Science		**2.96**	**2.88**	**3.17**
OVERALL AVG		**3.32**	**3.12**	**3.29**

*Alternate added to the cohort at the beginning of Spring 2010 semester **Transferred after Fall 2009 semester ***Left due to disciplinary reasons

Table 1. STEM Cohort GPAs and QPAs

Course Number	Course Name	Total Number of Students	Number of STEM Scholars	Percentage of STEM Scholars	Class Average GPA	STEM Average GPA
ASCI2010	Fundamentals of Act Sci	40	5	12.50%	3.33	*2.40
BIOL1310	Principles of Biology	90	3	3.33%	2.50	*2.00
BIOL1315	Principles of Biology Lab	24	3	12.50%	3.08	*2.67
BIOL2310	Principles of Biology II	31	5	16.13%	2.84	*2.60
BIOL2315	Principles of Biology II Lab	46	5	10.87%	3.41	*3.20
BIOL2370	Microbiology	59	3	5.08%	2.78	3.00
BIOL2380	Microbiology Lab	43	3	6.98%	2.74	3.00
CHEM1210	Chemistry I	83	13	15.66%	2.35	2.85
CHEM1215	Chemistry I Lab	70	13	18.57%	2.54	*2.38
CHEM2210	Chemistry II	54	5	9.26%	3.04	*2.80
CHEM2215	Chemistry II Lab	38	5	13.16%	3.13	*3.00
COSK1221	Argument and Research	55	16	29.09%	3.04	3.06
ECON1020	Principles of Macroeconomics	52	5	9.62%	2.31	3.80
ECON1030	Principles of Microeconomics	92	3	3.26%	2.24	3.33
EDUC2000	Schools and Society	25	1	4.00%	3.08	4.00
ENGR1010	Introduction to Engineering	24	7	29.17%	3.58	3.86
ENGR2160	Engineering Graphics	49	8	16.33%	3.61	3.63
FYSP1000	First Year Studies Seminar	25	21	84.00%	3.80	4.00
INFS1020	Intro Decision Support System	25	9	36.00%	3.00	3.44
INFS3184	C++ Programming	27	5	18.52%	3.33	*2.80
MATH1020	Pre-Calculus	63	5	7.94%	2.21	2.80
MATH2070	Calculus w/Analytic Geom I	51	11	21.57%	2.67	3.18
MATH2070	Calculus w/Analytic Geom I	33	3	9.09%	2.55	3.33
MATH2170	Calculus w/Analytic Geom II	33	1	3.03%	2.67	4.00
MATH2170	Calculus w/Analytic Geom II	59	12	20.34%	2.14	*1.75
MATH3090	Calculus w/Analytic Geom III	25	1	4.00%	2.56	3.00
PHYS1210	General Physics I	33	7	21.21%	2.61	3.14
PHYS1215	General Physics I Lab	64	8	12.50%	3.06	3.75
PSYC1010	General Psychology	49	6	12.24%	2.98	3.50
SOCI1010	Principles of Sociology	45	10	22.22%	3.58	3.90
STAT2110	Statistics	55	2	3.64%	2.00	2.50
STAT3150	Probability/Math Statistics II	15	1	6.67%	2.73	4.00
Overall GPA					***2.86***	***3.15***

Table 2. Course Summary for 2009-2010 Academic Year

dents out of seven in science had behavioral or health problems that affected retention as well.

When comparing the STEM Scholars academic performance to the other students in their courses for the 2009-2010 academic year, they did pretty well (Table 2). Out of all of the grades that were earned by the STEM Scholars, slightly greater than 88 percent were a combination of 'C's and higher. Of this total, there were 115 'A's which is 56.1 percent. The remaining 11.7 percent was comprised of eight 'D's, five 'F's, and 10 'Withdrawals'.

The STEM Scholars had a total combination of 32 different courses related to their majors that they had taken over the 2009-2010 academic year. In only 10 of these courses (seven were in science, two in mathematics, and one in engineering – all marked with an asterisk in Ta-

Focus Group 2009 Session #1 Themes	Focus Group 2009 Session #2 Themes	Focus Group 2010 Session #3 Themes
Responsibility Social life Freedom choice	Anxiety Shift in paradigm Misunderstanding of program	Program is a positive Togetherness Academic challenges Course issues Too much time on core Interest in engagement Similar goals

Table 3. Focus Group Meetings

ble 2), the STEM Scholars had earned an average GPA lower than the class average. In comparing the overall GPAs of the class averages and the STEM averages, the STEM Scholars had an overall average of 3.15, whereas the class average was 2.86. As a group, the STEM Scholars performed better than their peers in their classes.

Focus Group Team Evaluation

In addition to reporting the quantitative results, students were queried by an outside team of qualitative researchers who developed and administered a series of questions related to the first-year experience, using a focus group for data collection. These questions are in Appendix A of this paper. The themes generated from the responses are listed in Table 3.

The focus group meetings occurred during the initial first week of the program, two weeks into program, and one year later, in order to note any changes among the group over a one-year span. In the initial sessions, student responses revolved mostly around the first year experience typical of any freshman student, such as dealing with new-found responsibility, social life, and freedom to make choices (decisions). Two weeks into the program, we once again did a focus group meeting, with the student responses now shifting more toward program adjustment, program and course anxiety, and misunderstanding of the program.

After one year, the group that had lost four members responded in a very positive manner relative to their first-year experience. Their comments were much more specific to their first year experience in the program. They expressed satisfaction with the group learning community experience and showed an interest in university projects that would engage the group. Many students stated that they still have the original goals they formed in the beginning of the program that focused primarily in their disciplines of engineering, mathematics, and science. Some felt that they wished they had the opportunity to work in STEM areas rather than having to take core subjects. Students also expressed their opinion that the course work is challenging, and for the most part, beneficial for them. All in all, the transition from the summer of the first year to the end of the school year had been positive and very encouraging for the NSF grant program because of the Living-Learning Cohort.

Because self-efficacy and academic progress were identified as central to the purpose of this study, the themes in Table 3 were examined in relation to this concept. Self-efficacy can be thought of as the degree to which students believe that they are competent and capable of achieving expected learning outcomes -- in this case, learning outcomes being primarily STEM related. Self-efficacy has been shown to be a strong predictor of how students behave (Bandura, 1997). Of special importance here is the behavior of students in relation to the ways that they go about using learning strategies effectively.

One of the themes noted in Table 3 for Session #1 is *responsibility*. For the most part students realized that they needed to assume a different role than the one they had in high school. Students were very aware that their lives would change. Here we see what Piaget described as *disequilibrium* or in this case a sense that perhaps the way that they were able to succeed in high school might not be adequate for what was required for them to be successful in college (Piaget, 1964;1970). However, while students recognized that things would be "tougher" in college than in high school, most seemed fairly confident that they would be able to successfully make the transition, thus exhibiting a rather strong sense of self-efficacy. As can be seen however in Table 1, the success of students varied among the areas of mathematics, engineering, and science where all of the mathematics students achieved at least a 3.0 GPA, while only 50 percent of the engineering students and 60 percent of the science students did so. While this discrepancy could be attributed to a wide range of possible reasons (including initial achievement levels), it may suggest that ways to help increase a sense of self-efficacy should be explored. Bolstering the suggestion that self-efficacy is of particular importance in this program are the findings from Session 2 and Session 3, where students evidenced more anxiety and were now more worried about the academic rigor of the program.

Conclusion

Overall, the cohort's first year went well. Of the original 21 students in the cohort, four students left for various reasons, from transferring to other universities closer to their homes to leaving because of medical and disciplinary reasons. One additional student, who was chosen as an alternate at the start of the Spring 2010 semester, returned to Robert Morris University, but was no longer eligible for the scholarship because of financial ineligibility. The cohort was designed as a Living-Learning Cohort and this has had a significant impact on the retention rate as well as their academic performance overall.

The cohort as a whole outperformed their non-cohort peers despite the performance of the science majors within the cohort. The science majors did not do as well as their cohort peers in the other disciplines of engineering and mathematics as evidenced by the lower GPA average. For both the fall 2009 and the spring 2010 semesters, the average GPA for the science students was below 3.0, whereas the average GPAs for the engineering and mathematics students were all above 3.0. This was also seen in the science courses the students took over their first academic year. Seven out of the 12 science courses resulted in the cohort having a lower average GPA than their non-cohort peers. Even though the science majors performed lower than their mathematics and engineering peers, the cohort as a whole outperformed their non-cohort peers for both the fall and spring semesters, as well as the entire freshman year. The cohort has also demonstrated a successful adjustment to the university and a desire to remain together as a community of learners.

Finally, based on the data obtained from focus groups, we believe that this method of collecting attitudinal data should become a regular component of the program. Findings from this study suggest that ways should be explored to improve students' sense of self-efficacy that may lead to even higher levels of academic progress and with less variation among STEM majors.

Disclaimer: Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Dr. Kalevitch is the Dean of School of Engineering, Mathematics and Science at Robert Morris University. Dr. Kalevitch is committed to excellence in teaching and always promotes a student-centered learning environment. She has also proven herself to be a very effective researcher: her resume shows a substantial list of publications, including lab manuals, books, and journal articles. She serves as the member of Editorial Advisory Board for several national and international peer-reviewed scientific journals. She is currently a Project Director on a 5-year NSF S-STEM grant for $562,000 that brought 21 STEM scholarships to the university.

Cheryl Maurer is the manager of the science laboratories at Robert Morris University where she serves as a member of the Laboratory Safety Subcommittee and the Hazardous Materials and Waste Subcommittee. She has also been a member of the Women's Leadership Advisory Council since its inception in 2010. The council was formed to better engage women alumni and female students at Robert Morris University. She has also been involved in STEM Outreach programs such as the Science Bowl, Expanding Your Horizons (EYH), and Perfume Science workshops.

Paul Badger, associate professor of science and laboratory safety coordinator joined the faculty at Robert Morris University in the fall of 2005 and has taught courses in general chemistry, bio-organic chemistry, organic chemistry, toxicology, forensics, instrumental analysis, and physics. Paul also conducts SEMS workshops for middle and high school students and helps to direct the RMU summer forensic science camp. He has co-authored several papers on near-infrared-emitting Lanthanide complexes and reductively activated complexes of Mn, Cr, and W. He is currently collaborating with the RMU science faculty on research pertaining to soil and water chemistry.

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George Semich, Ed.D. is a professor of education and the director of the Instructional Management/Leadership Ph.D program at Robert Morris University. He was also the former Department Head of the Communications at RMU and the former Department Head of the Secondary Education and Graduate Studies. Semich also serves as editor for three publishers and publishes primarily in the area of technology, curriculum, learning theory, and general education theory and practice. In the past, he has worked for ETS for eighteen years and the Moon Area School District where he was Director of External Testing.

James A. Bernauer is an assistant professor in the School of Education and Social Sciences at Robert Morris University where he teaches quantitative and qualitative methods and educational psychology. Prior to teaching at Robert Morris, he taught at Boston College, Duquesne University, and the University of Pittsburgh. His research interests include higher education, K-12 education, and career and technical education as it relates to teaching effectiveness. He is especially interested in how secondary and elementary teachers in a school district can work together to build math competencies.

Appendix A

Focus Group Questions

Focus Group 1 (8/10/09)

1. Since this program uses a cohort model, what are your thoughts in participating in this learning community model?
2. How do you feel about working in a cohort these next few years?
3. How do you feel about working in a university learning environment?
4. What do you think about the campus as your new residence?
5. What would be greatest concern in being a part of this learning opportunity?
6. What excites you most about this program?
7. How do you feel about making this four year commitment?
8. How do you learn best as a student?
9. In what ways do you perceive college life to be different than high school?
10. What do you feel in your greatest strength as a first year college student? What about weakness?
11. What is your career goal after you complete this program?

Focus Group 2 (10/19/09)

1. What can you say about your experience in working together as a cohort?
2. Share your experiences in working in the university learning environment.
3. How has your experience living on campus away from home been?
4. Have any of your initial concerns changed from the start of this program? Explain.
5. What have you enjoyed most in this program?
6. If you could change one thing with this program, what would it be?
7. Have your learning needs and interests been met in this program? Explain.
8. Share what you like most and perhaps what you like least about college life.
9. Has your career goal remained the same or has it changed? Explain.

Focus Group 3 (10/11/2010)

1. What would you describe as one of the most beneficial aspects of this program? Why?
2. What part, if any, would you say was the least beneficial aspect of this program? Why?
3. Given the change from high school to college, what changes would you say had the most impact on you and why?
4. Faculty teach using many methods and approach, what statement can you make about on this subject after completing your first year? Explain.
5. What courses did you enjoy most and why?
6. What courses did you enjoy the least and why?
7. After living on campus, what statement can you make about the independence and responsibility of living away from home?
8. Given this program is focused on math and sciences, what statement could you make on the academic rigor of your coursework? Explain.
9. If you could change anything with this program, what would it be? Explain.
10. Early in the program personal goals were discussed, from your perspective define your future goals upon completion of this program. Have they remained the same or changed? Explain.