

Advancing Diversity Initiatives in the Civil Engineering Profession: Impacts of an NSF S-STEM Grant at a Regional Undergraduate Teaching Institution

Dr. Mary Katherine Watson, The Citadel

Dr. Mary Katherine Watson is currently an Assistant Professor of Civil and Environmental Engineering at The Citadel. Prior to joining the faculty at The Citadel, Dr. Watson earned her PhD in Civil and Environmental Engineering from The Georgia Institute of Technology. She also has BS and MS degrees in Biosystems Engineering from Clemson University. Dr. Watson's research interests are in the areas of engineering education and biological waste treatment.

Dr. Kevin C Bower P.E., The Citadel

Dr. Kevin Bower is D. Graham Copland Professor of Civil Engineering and Head of the Department of Civil and Environmental Engineering at The Citadel, Charleston, South Carolina. Dr. Bower's research into teaching and learning focuses on improving active learning environments and the development of principled leaders attributes in engineering students.

Dr. William J. Davis P.E., The Citadel

William J. Davis is a professor in Civil & Environmental Engineering at The Citadel in Charleston, SC. He received his Ph.D. in civil engineering from Georgia Tech and is a registered professional engineer. His research interests focus on infrastructure resiliency, transportation facility planning and design, highway safety, and active living by design. He teaches courses in capstone engineering design, engineering management, transportation engineering, geographic information systems, and land surveying.

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A student scholarship and enrichment program was established in 2012 to help address the persistent problem of underrepresented minority, female and socioeconomically disadvantaged students enrolled in civil engineering degree programs and corresponding small number of graduates who enter the civil engineering profession. The program was administered within the civil engineering department of a regional undergraduate teaching institution and was made possible by funding from the National Science Foundation's Scholarships in Science Technology, Engineering and Mathematics (S-STEM) program. The S-STEM program at our institution, entitled Excellence in Civil Engineering Leadership (ExCEL), offered scholarships to qualified students, within target demographic groups, to obtain financial and educational support in earning a civil engineering degree. Equally important to financial support, ExCEL faculty provided a variety of program-specific, student support services focused on improving retention, building a supportive learning community, developing principled leaders, and preparing graduates for successful careers.

Institutional Context

The Citadel is a state-funded, public institution. Students interested in receiving an ABET-accredited Civil Engineering Bachelor of Science (BSCE) degree have two enrollment options: (1) enroll in the cadet program and receive a BSCE degree along with leadership development training through a military student life setting, or (2) enroll in a 2+2 civilian program offered through coordination with a local technical college.

Students who enter the Corps of Cadets live and study under a classical military system with leadership and character development as an essential part of their day-to-day educational experience. The mission of the cadet program is to educate and prepare graduates to serve as principled leaders by instilling core values focused on academics, duty, honor, morality, discipline, and diversity. The high ethical calling of engineering students is further supported through the unwavering devotion to the honor code, which states, "A cadet does not lie, cheat, or steal, nor tolerate those who do." Additionally, the institution's curriculum and student development program include eight semesters of ROTC military leadership instruction and student-centered barracks campus life focusing on moral and ethical leadership principles.

Students who enter the 2+2 program, which is offered in conjunction with Trident Technical College, attend Citadel evening courses beginning in their junior year. The curriculum for these two years of the program is exactly the same as the daytime cadet program and is taught by the same civil engineering faculty.

Summary of ExCEL Program Structure and Support Services

Students were selected for admission into the ExCEL program based on financial need and academic performance. Financial need was determined based on students' submission of the Free Application for Federal Student Aid (FAFSA) and the Federal Methodology formula. Incoming freshmen were required to have a 1250 SAT score and a 3.8 high school GPA. To further assess a student's potential for success in the program, potential recipients were required to participate in an interview and submit a civil-engineering focused essay. Once selected as a scholarship recipient, students were required to maintain a 2.75 GPA during their freshman year and a 3.00 GPA during subsequent years.

In total, three cohorts of freshmen were formed between 2012 and 2014. Cohorts were initially composed of students enrolled in the cadet program. Students enrolled in the 2+2 program are not admitted to The Citadel as freshmen; therefore, it was not feasible to include them in freshman cohorts. However, as cadet scholarship recipients became ineligible, 2+2 students were considered as replacements in junior-level cohorts.

To encourage persistence in civil engineering, each ExCEL cohort was organized into a learning community. Students from the same cohort were block scheduled in the same courses and also assigned to live in the same on-campus barracks to facilitate enhanced integration into the institutional culture and involvement in classroom activities. All cohorts received group and individual advising from ExCEL faculty to ensure successful progression in the civil engineering curriculum.

Freshmen cohorts in particular were provided with unique support services to aid in their transition to college-life. Before beginning their freshman year, students participated in The Citadel's College Success Institute (CSI) to prepare them for the academic and military rigors of The Citadel. During this summer experience, students completed a math placement test. Those ExCEL students who did not place into Calculus I were given an opportunity to complete Precalculus during the summer session to ensure that they were prepared to begin Calculus with their assigned cohort during the Fall semester. Those ExCEL students who did place into Calculus I were given an opportunity to complete a humanities elective. Once beginning their freshman year, students met individually with a learning strategist to discuss academic demands and strategies for becoming independent learners. Meetings with their instructional strategist continued through their sophomore year, although the frequency was reduced to once per month.

Additional support services were provided to students through weekly meetings with ExCEL faculty. Approximately each week during the semester, students from all cohorts participated in an academic and/or professional development activity:

- Site Visits: To aid students in identifying and developing their interests within the civil engineering sub-disciplines, students participated in site visits to a variety of local civil engineering companies and project sites. Examples of site visits included trips to a

wastewater treatment plant, a humanitarian engineering non-profit organization, a power company, and several construction sites.

- **Service Learning Projects:** Each Fall semester, freshmen and sophomores planned and participated in an interactive outreach event to teach elementary school students about civil engineering. Each Spring semester, students coordinated with The Citadel’s Society of Women Engineers chapter to participate in an outreach activity to introduce middle-school-aged girl scouts to STEM fields.
- **Campus Engagement Activities:** On-campus field trips were organized to keep students engaged with engineering aspects of their campus community. As on-campus facilities (e.g., buildings, coastal infrastructure, maker spaces) were maintained and constructed, students met with relevant project managers and engineers.
- **Professional Mentoring:** Students participated in a variety of formal and informal mentoring activities. Speed-mentoring and small group mentoring events were coordinated. Many students also elected to participate in a school-wide program to connect students with a personalized professional mentor.
- **Diversity and Ethics Workshops:** Students attended several workshops focused on ethics and inclusiveness in professional practice.

Recruitment and Retention of ExCEL Students

In total, 34 students were recruited into the ExCEL scholarship program. Of the 34 students, 17% were female and 37% were minorities. Consistent with the mission to increase access to civil engineering education, all students not from a traditionally underrepresented group (i.e., females and/or minorities) were from a rural county in South Carolina (Tables 1-2).

Table 1. Scholarship recipients by gender.

	Percentage of Total Scholarship Recipients (<i>N</i> = 34)	Percentage of Total Scholarship Dollars (\$522,377)
Male	83%	74%
Female	17%	26%

Table 2. Scholarship recipients by race/ethnicity.

	Percentage of Total Scholarship Recipients (<i>N</i> = 34)	Percentage of Total Scholarship Dollars (\$522,377)
White	63%	77%
Hispanic or Latino	11%	3%
Black or African American	14%	9%
Asian/Pacific Islander	9%	7%
American Indian/ Alaska Native	3%	4%

Overall, over 75% of all ExCEL students persisted in civil engineering. In fact, over 80% of female participants and over 60% of minority participants graduated or will graduate with civil

engineering degrees. The most common reason for exiting civil engineering was poor performance in either pre-calculus or calculus. Specifically, math was a significant barrier to persistence for 50% of all female and 60% of all minority students leaving civil engineering. In addition, over 25% of all existing students cited chemistry as a significant barrier to persistence, while 20% decided that they were not interested in the field of civil engineering (Tables 3-4).

Table 3. Retention of scholarship recipients by gender and race/ethnicity.

	Percentage of Total Recipients (<i>N</i> = 34)	Percentage of Total Female Recipients (<i>n</i> = 6)	Percentage of Total Minority Recipients (<i>n</i> = 12)
Retained within Civil Engineering	77%	83%	62%
Retained within non-STEM Program	6%	0%	18%
Left The Citadel	17%	17%	20%

Table 4. Common barriers to persistence by gender and race/ethnicity.

	Percentage of Recipients Leaving S-STEM Program ¹	Percentage of Female Recipients Leaving S-STEM Program	Percentage of Minority Recipients Leaving S-STEM Program ¹
Poor Math Performance	53%	50%	60%
Poor Chemistry Performance	27%	0%	30%
Lack of Interest	20%	0%	10%
Other	27%	50%	30%

¹Percentages do not add to 100% because students could cite more than one barrier to persistence.

Student Perceptions of ExCEL Program

Student perceptions of the ExCEL program are currently being gathered to provide insights for future improvements. A survey (consisting of Likert scale items and open-ended questions) was administered to students participating in the program during the Spring 2015 and Spring 2016 semesters. Students were asked to rate the impact of a variety of support services using a five-point scale. Overall, students indicated that the most impactful elements of the program were block scheduling of classes and group advising sessions (Table 5).

Table 5. Student perceptions of academic and personal support services.

<i>To what extent did the following opportunities contribute to your success as a civil engineering student? [1 – 5]</i>	Avg. for Spring 2015 Participants (<i>n</i> = 16)	Avg. for Spring 2016 Participants (<i>n</i> = 10)
Living in common barracks	4.2	4.3
Block scheduling	4.4	4.7
Citadel Success Institute (CSI)	4.0	4.3
Meeting with instructional strategist	3.6	4.1
Group advising sessions	4.3	4.7

Students were also asked to provide feedback on the extent to which participation in select activities impacted development of civil engineering professional skills, as defined by the discipline’s body of knowledge (BOK2). Students participated in a series of diversity workshops, modeled after the National Coalition Building Institute, throughout their junior and senior years. Students indicated that these workshops most significantly impacted their *respect and tolerance for diversity in the workplace* and *ability to apply standards of professional and ethical responsibility in the work place* (Table 6). In addition, participation in community outreach events most significantly impacted students’ *ability to communicate engineering concepts to a non-technical audience* (Table 7).

Table 6. Impact of diversity workshops on students’ professional skills.

<i>To what extent did participation in the NCBI diversity training positively impact your [1-5]:</i>	Avg. for Spring 2015 Participants (<i>n</i> = 16)	Avg. for Spring 2016 Participants (<i>n</i> = 10)
Ability to describe why diversity is important for improving the field of civil engineering	3.4	4.1
Respect and tolerance for diversity in the workplace	3.6	4.2
Ability to participate on diverse teams	3.5	3.8
Ability to lead a diverse team	3.2	3.7
Ability to apply standards of professional and ethical responsibility in the work place	3.6	4.2

Table 7. Impact of participation in community outreach events on students’ professional skills.

<i>To what extent did participation in community outreach events positively impact your [1-5]:</i>	Avg. for Spring 2015 Participants (<i>n</i> = 16)	Avg. for Spring 2016 Participants (<i>n</i> = 10)
Ability to communicate engineering concepts to a non-technical audience	4.3	4.6
Ability to organize and lead a team in accomplishing a technical goal	4.0	4.3

Insights for Future Programs

Based on analysis of recruitment and retention data, as well as students’ perspectives, we have identified programmatic elements that should be included, modified, and/or removed from future programs (Table 8). Many of the academic, professional, and personal support services were helpful for students, although a more formal seminar structure will be used in the future to encourage accountability and consistent use of these services. Also, appreciation for and promotion of diversity and inclusiveness are important professional skills. Student perceptions support that the workshop structure was not most effective for guiding students in developing these professional skills. Perhaps providing opportunities for students to engage with diverse portions of the community will be more impactful in the future.

Table 8. Insights for future S-STEM programs.

Program Element	Successes	Weaknesses	Insights for Future S-STEM Program
GPA Requirement	High GPA requirement made students' cognizant of the importance of academic performance.	Difficult for students to rebound if they performed poorly during any particular semester, especially early in their academic careers (which is a particular problem at a residential senior military college).	Set minimum GPA at 2.5 for Freshman retention and then 2.75 thereafter.
Block scheduling	Supported cohesion within cohorts and development of study groups, especially during formative freshmen and sophomore years.	For upperclassmen, study groups were already well-established and block scheduling became not feasible due to students' differing course requirements.	Retain early registration for all cohorts. Retain block scheduling for freshmen and sophomore cohorts.
Common Barracks	Facilitated development of a learning community during freshmen and sophomore years.	Created some tensions as students lived in the same barracks and took all of the same classes.	Initially place students in the same barracks as freshmen, but allow them to transfer in later years.
Weekly meeting structure	Cohesion within/across cohorts. Informal structure allowed for positive faculty-student interactions.	Lack of course credit led to some issues with student attendance. Informal nature of meetings made organized reflection activities difficult.	Inclusion of a seminar each semester. Expected to resolve accountability issues and facilitate integration of academic/professional development activities.
Weekly meeting activities	Site visits, service learning, and professional mentoring helped students develop professional identity and skills.	Many students expressed dissatisfaction with diversity workshops, citing that they were disconnected from professional practice.	Continue site visits, service learning, and professional mentoring. Encourage students to interact directly with diverse portions of the community (rather than workshop structure).