Developing Inclusive Excellence in Engineering Education: Lessons from the Wisconsin Louis Stokes Alliance for Minority Participation Excel Program

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Abstract

Efforts to broaden participation in science and engineering (STEM) are of national importance. This paper describes the development and implementation of teaching strategies for the Wisconsin Louis Stokes Alliance for Minority Participation (WiscAMP) Excel program. The program involves: 1) selecting underrepresented minority (URM) students majoring in science and engineering whose first year academic performance indicates they are at risk for leaving STEM; and 2) providing an intensive 8-week immersion experience in STEM scholarship, research, academic and career exploration and advising. Collectively program faculty members have identified a shared programmatic strategy with respect to supporting students' cultivation of a growth mindset [1], which has been shown to increase student persistence and performance while decreasing their vulnerability to stereotype threat. The program has been ran 6 times, enrolled a total of 110 participants, 99% of whom are URM students majoring in STEM. Upon completion of the program, participants report increased confidence in their abilities to succeed in their STEM coursework and a stronger commitment to their career. Follow-up data indicate 67% of program participants are persisting in their majors or have graduated with a STEM degree. Strategies for cultivating a growth mindset in the classroom are presented and discussed.

Entity and Incremental Theories

Beliefs about the nature of ability influence a host of variables including motivation and achievement in the face of challenge or difficulty. Some individuals tend to believe that intelligence is fixed, not changing over time or across contexts, an "entity theory." Because they believe that ability is fixed, entity theorists [2] are highly concerned with messages and outcomes

that supposedly reflect their "true" abilities. When facing challenges, entity theorists tend to demonstrate lowered focus and task avoidance. Others tend to view intelligence as a quality that can be developed and that it changes across contexts or over time, an “incremental theory.” Incremental theorists tend to be more focused on improving rather than proving ability to themselves or others [2]. When facing challenge, incremental theorists are likely to increase effort to further learning and to overcome obstacles. Although many studies have treated implicit theories of ability as individual difference variables, studies have shown that these beliefs themselves can be altered (at least on a short-term basis) by modifying how abilities are described and the specific nature of feedback.

Fixed and Growth Mindsets

The beliefs instructors and students have about the nature of ability can have important consequences for the teaching strategies they adopt and their motivation to engage in effort to learn new skills. C. Dweck [1,2] describes a fixed ability mindset as the belief that ability is a static, enduring characteristic of individuals. The fixed ability mindset assumes that abilities can be assessed, but little can be done to change abilities. In contrast, the growth or developing ability mindset is the belief that ability at any given point in time is subject to change and improvement. The growth mindset assumes that abilities develop and improve when a person engages in appropriate learning activities, receives effective formative feedback and makes an effort to learn from these experiences.

The Excel Program

The program involves eight weeks of summer school. Room, board, and a stipend are provided. In turn, students commit to participate fully in all classes and activities and to be on time. The program has classes Monday through Thursday, including classes on mathematics, science and on communication and study skills. Fridays feature enrichment activities and field studies.
In the mathematics class, students are divided into groups to accommodate their different skill levels, as determined by their completed math courses and their results in a standardized placement test, and thereby ensuring students have ample opportunities to master content and receive feedback on their performance. Students work individually and in groups, again ensuring that students have access to vicarious learning experiences. The syllabus is designed in such a way that, after eight weeks, students are working on topics one course level higher than at the beginning of the program.
The science class is divided in three segments: biology, chemistry and physics. All students take the 3 classes and they are not divided into groups to account for initial knowledge level. Rather, all the instructors work together to create a unified mathematics, science and engineering experience revolving around a common topic, for example: energy, to be studied from their respective points of view. This is an integral part of the student experience and is used not only to show the students the interdisciplinary nature of research in STEM disciplines but also to set the tone in terms of expectations during the workshop. Pre-assessment and post-assessment is carried out to evaluate conceptual understanding.
The communication and study skills class has an emphasis on career and academic major advising. Pre-assessment and post-assessment are carried out by means of essays intended to measure writing and composition skills. During the eight weeks, students engage in independent

projects such as developing their academic plans for declared and alternative majors, making a thoughtful response to selected readings, conducting an informational interview with a professional in their intended field, reporting on best practices, and participating in a juried poster presentation of a small research project.
Overall, the curriculum is designed so that the task difficulty is slightly greater than students' current ability as established by their transcripts and pre-assessment results. Students are exposed to vicarious successes and role models, with opportunities to present successes and correct errors. Each student's performance gets honest feedback, with specific information about how to improve their skills and performance. Instructors and staff meet regularly to monitor students' work and to evaluate the qualities of the learning environment---specifically to ensure that the classroom and activities create a positive, supportive, and safe space for students.

Student Recruitment

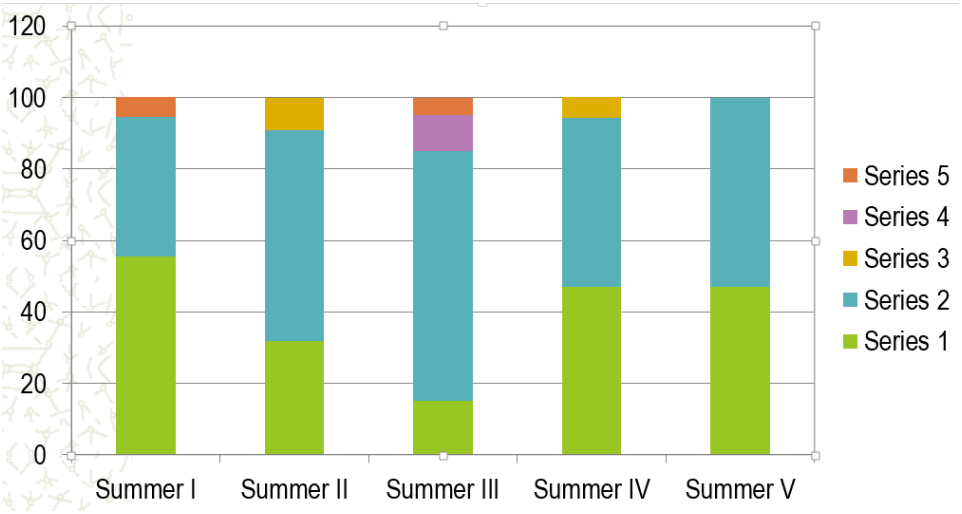
Across all 6 years of the Excel Program, 149 students have applied. One hundred and twenty students were invited to participate and 110 of them accepted the invitation to be part of the program. Students were selected on the basis of how closely they fit the criteria of majoring in STEM, holding a minimum GPA of 2.0, and rising sophomore status. Depending on the pool of applicants, the criteria for GPA or rising sophomore standing were sometimes relaxed in order to ensure a sufficient enrollment. The only criterion that was never relaxed was the student's declared or intended STEM major. Review of application materials showed that 39% of program participants were from the biological sciences, 14% from the physical sciences and 42% from engineering. The median GPA across all 6 years for students who participated was 2.7. The GPA's associated with the 25^{th} and 75^{th} percentiles are, respectively, 2.4 and 3.1. The Louis Stokes Alliance for Minority Participation (LSAMP) defines URM groups as Black/African American, Hispanic/Latino, Native American/Alaskan Native, Native Hawaiian or Pacific Islander. The proportion of URM students over the first 4 years of the program is 87%, with the lowest value (82%) in the initial program year. However, these figures underestimate the proportion of URM insofar as the State of Wisconsin includes Southeast Asians (Hmong, Lao, Cambodian, etc.) as URM. All but one of the non-URM students by NSF standards self-identified as Asian. According to program staff almost all of these students were born in or had a parent born in the former Indochina. Inclusion of Southeast Asian students increased URM representation in the program to 99%.
With respect to students' rising sophomore status, 60% of the students across all 6 years reported that they were sophomores. In the first year, nearly 59% of the students were either juniors or seniors, in part a result of relaxed criteria to ensure enrolling the first pilot of the program to capacity. An additional consideration concerns how "sophomore" is defined. Staff interviews and an analysis of progress towards the intended STEM major revealed that some, but not all, of the junior and senior students were effectively sophomores with respect to their progress in their STEM major. Student transcripts confirm this assessment. These outcomes suggest that the Excel Program recruitment strategies have been successful in attracting applications from its target audience, underrepresented minority students at risk of leaving a STEM discipline for academic reasons.

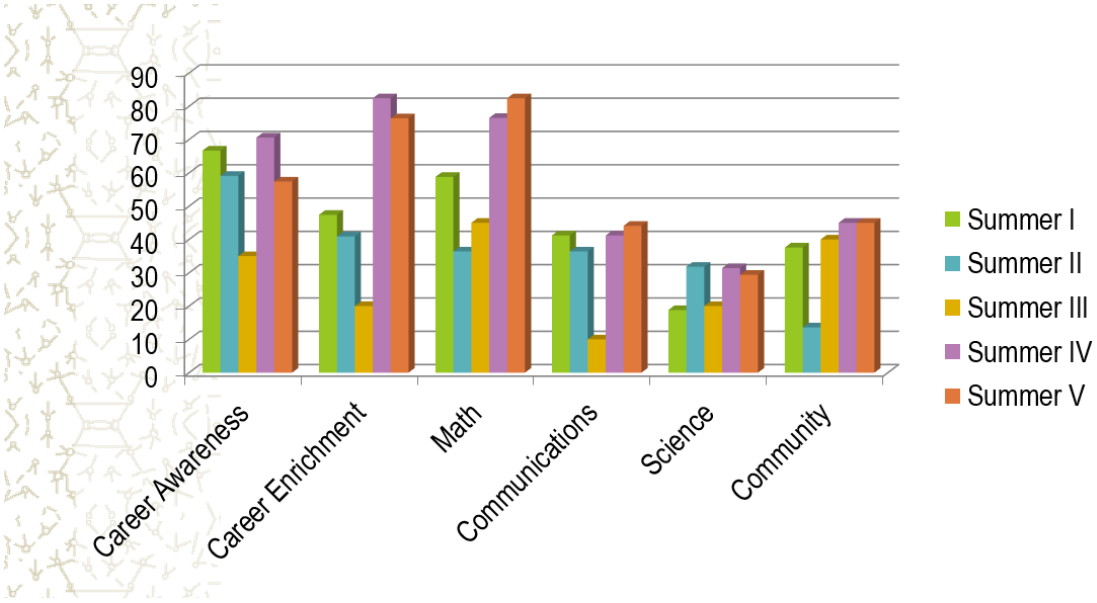
Retention and Success in STEM

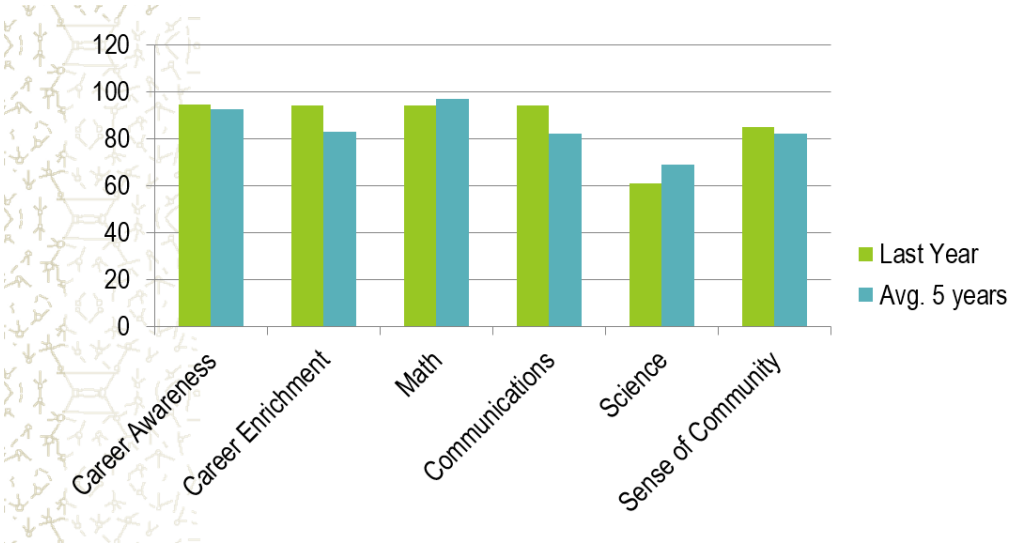
Former students are tracked through e-mail contact, Facebook updates, and consultation with STEM faculty and advisors who work with WiscAMP Excel students. WiscAMP Excel has 66% overall retention/graduation which compares quite favorably to 5-year degree completion rates which hover around 20% nationally for URM students majoring in STEM [3,4]. Only the 2009 and 2010 cohort are viable for assessment of graduation in STEM as of spring 2014. Most students enrolled in the first pilot of the program were rising juniors in terms of their years enrolled and credit hours. However, many of the students accepted into the program were at sophomore level with respect to their progress in their STEM majors. The graduation rate in STEM for this first pilot of the program is 59% and an additional 24% were still persisting in their STEM majors as of spring 2013. Additionally, the graduation/retention rates for WiscAMP Excel participants are slightly higher than for WiscAMP non-Excel participant. This is a positive result given that the Excel Program targets students at risk of leaving STEM majors.

Exit Surveys

In exit surveys given at the end of each one of the Excel Program pilot offerings, students were asked about their level of satisfaction overall and with each one of the components of the Excel Program. The results, as seen in the figures below, show increasing levels of overall satisfaction (figure 1 shows 94% in 2009 to 100% in 2014) as well as increasing levels of satisfaction with each one of the components of the program. Work continues in trying to refine the philosophy, content, delivery and assessment methodology of the Excel Program.







Conclusions

Summarizing some of the most important lessons learned so far from the pilot runs of the Excel Program:

1) Staff and instructors need to understand and believe in the benefits of a growth mindset academic environment.
2) Students participating in the program need to be carefully screened and made aware of the expectation of academic engagement during the program. The stipend, approximately $3,000, is intended to allow the students not to have to work during the summer.
3) The curriculum for the program needs to be flexible as to best accommodate the academic needs of the students as determined by pre-assessments.

4) Excel-like programs are resource intensive because of the number of personnel (administrative support, instructors, guest speakers) and field experiences involved.
5) The outcomes (retention/graduation rates and exit surveys) of the pilot run of the program measured so far bode well for the potential impact of the WiscAMP Excel Program on URM student success in STEM.

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