Improving the Undergraduate Experience: Supporting Underrepresented Students in STEM & Computing
Multiplex Theme of the Month Synthesis: August 2021

Introduction

The August Theme of the Month, focusing on improving the undergraduate experience, with a particular focus on supporting underrepresented students in STEM and computer science, provides a lens into a dynamic area of experimentation and research. It has been established for some time that STEM education is in need of significant transformation at the university level no less than in primary and secondary school (AAAS 2011). Students' active engagement has been shown to increase their persistence in a course of study, improve their sense of self-efficacy, and sometimes also to improve their understanding of content (Kober 2015, Haak et al. 2011, Glynn and Koballa 2006). The transition into college can be particularly important: The Boyer Commission in the late 1990s identified the first years of university as decisive in students' decisions about their future studies and careers (Boyer Commission 1998).

The increasing emphasis on faculty research at all levels of higher education (Schuster and Finkelstein 2006) has been met in recent years by a sense that teaching and learning need to be reclaimed as a central activity of university faculty (Berg and Seeber 2016, PCAST STEM Undergraduate Working Group 2012, Biggs and Tang 2009, Altbach et al. 1999). Numerous strategies have emerged for the redesign of undergraduate STEM education, aiming to make instruction more engaging and more effective in producing good learning outcomes. Such changes require an examination of the functions of various parts of a typical course —lecture, reading, homework assignments or problem sets, labs or other practical work, and assessments (Kober 2015, NAS 2015). Along with this experimentation with curricular design, there are also multiple promising, research-based strategies intended to make undergraduate education more student-centered, to build student engagement and student voice in the science classroom, and to improve conceptual understanding and sense of efficacy in science practice (Freeman et al. 2014, Mulnix 2013, Haak et al 2011, Deslauriers et al. 2011).

Some professors and institutions are exploring ways to involve undergraduates in the actual practice of science, whether in course-based research experiences (CUREs) (Corwin et al. 2015, Auchincloss et al. 2014), or the design and execution of their own research, far earlier in their career than has historically been the case.

As our expert panel, and the resources they provided make clear, this student-centered approach, while it is promising as a way to bring more students into the STEM "pipeline" or "pathway," is particularly important for underrepresented minorities (URM) in STEM. The experts told us of the promising work that they are engaged in, to deepen and apply this student-centered orientation to invite and involve URM students in STEM and computer science.

The Expert Panel

Dr. Ann Gates, the Senior Vice Provost at the University of Texas at El Paso, served as the moderator. She directs the Computing Alliance for Hispanic Serving Institutions (CAHSI). CAHSI is one of NSF's National Includes Alliances that promote the importance of inclusion and equity in advancing innovation and discovery. The other panelists were Dr. Preeti Gupta, who leads strategic planning and program development at the Museum of Natural History; Dr. Maria Santisteban, Professor of Biology at the University of North Carolina at Pembroke; Jasmin Graham, Marine Biologist at the Marine Science Laboratory Alliance Center of Excellence and President and CEO of Minorities in Shark Sciences; and Dr. Patricia Morreale, the Director of the School of Computer Science and Technology at Kean University.

Mentoring and Identity
The underrepresentation of minorities in the STEM and CS professions in fact contributes to the continued underrepresentation of these minorities as scientists, mathematicians, and engineers. Youth do not see many people like them in such roles, so that it is hard for them to see themselves in such a future career (Atkins et al. 2020). Mentoring can play an important role in addressing the complex issues of identity.

> *One of the things that we're focused on is science identity. Science identity, self-efficacy, and sense of belonging....we ask the interns to identify in the beginning and the end, How much of an overlap is there between a science person and themselves? In the beginning of the internship, we see that most interns are falling into this category. Either they don't see themselves as a science person at all, or they say, "Oh, well, I guess I'm kind of a science person." Then by the end of the internship, we're seeing them here, where there's almost entirely an overlap between themselves and a science person. That's really great to see. -- Jasmin Graham*

Graham points out that, while the program's backbone is internships that involve youth in research experiences in marine science, it is important to understand and respond to the other factors that can divert interested students from following an interest in a STEM/CS career. For example, students' academic preparation may not be adequate yet to undertake a STEM/CS undergraduate program. Financial commitments, for example to work to help support their family, may limit the amount of time the students have to participate in the internships. The programs therefore have found ways to alter their schedules to allow part-time participation or make available supplemental time for background study.

Moreover, it has been clear from early on that mentor scientists or graduate students may need some preparation and coaching to make the internships successful for the interns and for their own work as well. Preeti Gupta and Patricia Morreale sketched what this entails in their programs.

> *There is intense mentor preparation curriculum that starts off and includes everything about what it means to work with youth, with urban youth, and goes from thinking about issues of equity and inclusion, but also operational issues, and how do you support young people to meet their deadlines? -- Preeti Gupta*

> *Faculty development on mentoring students is very important, and then we put the faculty into a cohort. They met regularly. We ran an eight-week program in 2020. A little bit shorter this summer because we've replicated the experience again. In 2020, we had about 51 students meeting nationally with 21 faculty from a variety of schools. -- Patricia Morreale*

Reaching Students Before College
The sense of "belonging," of coming to see oneself as a STEM/CS person, can come about in many ways, but having time and opportunity to learn, in the company of others who are similarly interested and involved can make a significant difference in one's developing identity. Preeti Gupta talked about the science research mentoring program, which the American Museum of Natural History participates in as part of a consortium of universities, other museums, community-based organizations, and hospitals. Groups of three to four young people, chosen to reflect the city's diversity, are paired with a research scientist at the Museum. The internship is intensive — perhaps 100 contact hours — and engages the students in the doing of natural science. It makes them part of the continuum of people, with different levels of skill and experience, that make up a research team, and they are also learning, sometimes implicitly and sometimes explicitly, the culture of the lab in which they are interning.

What's important here is that the youth work in small groups with the scientist, and they are doing authentic science research, just like what Jasmin was describing. They're actually doing work alongside the scientists. They're joining that community of practice. What that means is that they are part of that practice, they are part of that community. They're giving back to that community; they are taking from that community. They're learning the rules, the tools that are contributing knowledge to that community.... At the end of their research, which is at least 100 hours of research time, whether it's all concentrated in the summer, or maybe it's spread throughout the year... the students do posters and papers and many times they get co-authored on publications and other ways that scientists normally would get their work out.

Several panelists agreed that in seeking diverse students to participate in such mentoring programs, potential mentors and program organizers should look past obvious qualifications, such as high grade-point averages, and see out and recruit students who may not be "stars," but give clear evidence of interest and intrinsic motivation to get involved in STEM research and learning. As Preet Gupti said of the AMNH program.

We really are trying not to take A students, the best GPA students. We're really trying to take those students who are at the cusp of being interested in science and motivated by science but are not necessarily getting As and are for sure going to go into those colleges and careers that are STEM. We're looking for those students who might be on the fence because they may have reason to believe they don't belong, or they're just not good enough or they're getting messages externally that they might not hack it.

Diversifying Strategies to Enable Students from Underrepresented Groups

Patricia Morreale spoke of CAHSI's "asset-based approach" in their work with URMs in computer science. Asset-based education (see here for a useful overview) takes seriously the insights of socio-cultural approaches to learning, such as the "funds of knowledge" approach pioneered by Luis Moll and others, and works to see and work from students' strengths and interests, rather than starting from an identification of deficits to be corrected. This approach sets student learning and identity-building as a collaborative process within a learning community including experts, novices, and people in between (such as graduate or undergraduates in the field); they have implemented an "affinity research group" model (see Resources by Ann Gates and others). Challenged by COVID, however, CAHSI was able to apply these principles in developing an alternative approach, which has explicit learning goals for all participants, not just the "target" students.

With COVID, all of the offers for physical research opportunities for undergraduates were really rescinded. Our universities closed, and the generation of scholars that we were hoping to encourage, we were very fearful it was going to be lost....With the help of an NSF rapid grant, however, we were able to build a virtual community for both our faculty and our students, and we were able to share with them this opportunity for undergraduate research experience, which is absolutely vital in building their identity and making sure they move forward as a scientist. Our goals with the virtual research experience that we develop for our students is first of all faculty development.

Addressing the Whole Person

Marie Santisteban described the approach taken at the University of North Carolina at Pembroke, which is a school with deep ties to the Lumbee Nation, among other populations that it serves. In committing to encourage students majoring in biology and chemistry to succeed in their studies, and continue into STEM fields post-graduation, the school has taken a multi-element approach integrating several kinds of support.

The program pillars are really financial support, academic support, career support and community building. The financial support, as I say, it's a very important one in here. It first will allow some students to attend college, period. Secondly, it will allow students to attend college without the distractions of having to work outside to make a living. A lot of our students were taking very long to graduate, sometimes more than six years, and many times it's because they're trying to support their families, they're trying to pay for their own education.... Our students really needed a lot of information about graduate school careers in science. The lack of role models was really something that was pretty obvious early on. These are, many times, first generation students in a rural area, they don't really have a lot of references. If they are good students, they typically want to go into a health career because that's what they are used to see. We try to make students see that they can give back to their communities, even when they are going to be scientists as opposed to a doctor. This region is the birthplace or the cradle of the Lumbee tribe, and the ties to the community are very important to them. Make them see that those things are possible.

Benefits to Faculty — and Costs

Finally, as so often in scientist-school partnerships, the issue of incentives and benefits to the faculty comes up, given the typical rewards and imperatives under which faculty, especially junior faculty operate. (See here for one person's view of the rewards of mentoring for scientists.) Our panelists spoke of different ways that they help faculty mentors see multiple benefits from the time and effort they invest in their mentorship.

By structuring it as helping the professor's personal portfolio, and how will you find those students, and how can we make sure that we're moving you along to your personal goals, that helps. There are also a number of recognitions available for talented faculty mentors. I try to put my faculty forward for those prizes and awards. Whether it's at the university level or at a national level, and undergraduate research, mentoring is becoming much more valued and respected.... always encourage faculty to refresh the pond, if you will. Look for the new folks, the new voices and make sure that we're moving everyone along to success. -- Patricia Morreale

Recommendations for Researchers

Mentorship comes in a wide variety of realizations, from more structured and programmatic to more informal kinds of expert-novice support or apprenticeship (and indeed "some literature suggests informal relationships may be more successful" (Atkins et al 2020, pg. 3)). Our panelists and the resources they provided point out how much innovation is happening in this area – and how little is yet known about the strengths and weaknesses of the many models that seem anecdotally to be successful. Both design-based research and cultural-historical activity theory model (CHAT) could be fruitful frameworks for deep investigation of the mentorship programs designed to broaden participation in STEM/CS.

Other questions important to be probed include:

- In what ways does mentoring (in some form) shape scientific identity for students from under-represented minorities? This question was posed by Atkins et al. 2020, but much more needs to be learned.
- How does the enhancement of a student's science identity interact/conflict with other aspects of student's identity, such as place identity, or the sense of community participation and responsibility?
- What in fact are good measures of "success" for the kinds of mentoring advocated by the expert panelists this month (e.g., persistence into post-graduate life, changes in identity/self-efficacy, enlarged networks)? In the context of the need to diversify STEM/CS fields, what kinds of

success are of most interest for the development of practitioners? Of a new and larger cohort of diverse STEM/CS teachers at all levels of education? For the improvement of the public understanding of STEM/CS?

- In renewing undergraduate STEM/CS education, how do research-based mentorship programs interact with (reinforce?) other efforts at curricular and pedagogical change in undergraduate education, as mentioned in the introduction?

Recommendations for Administrators

Many administrators, especially at secondary and tertiary levels, have become interested in some form of mentorship for their students or their STEM/CS teachers. Since as has been emphasized mentorship models are various and often experimental, administrators need to take care that the design, participation, and evaluation of such programs is carefully monitored to ensure they truly encourage broadened participation, that the mentors are supported (and trained) to offer good-quality mentorship, and that a broad range of metrics for success (and formative development) is considered for each component of the program — mentors, mentees, school, and community. The literature on funds of knowledge and of "asset-based education" will be a great help to schools wishing to participate in, or help design, a mentorship program.

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