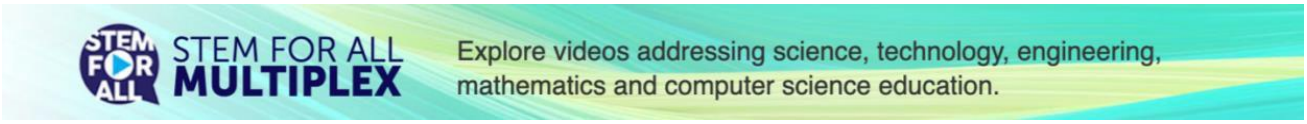

Broadening Participation in STEM by Focusing on Identity Development
STEM for All Multiplex Synthesis: May 2023

The May 2023 Multiplex Webinar, moderated by Dr. Iris Wagstaff (and discussed in her excellent introductory blog post), framed science identity around two dimensions. She said:

> *We know from the research that STEM identity has two main dimensions. One is how individuals perceive themselves with respect to science related efforts and activities, and the second agreed upon definition or dimension in the field is how others perceive individuals with respect to science related efforts and activities.*

Science identity is an important concept for understanding the experience of young people from groups historically under-represented in STEM. Research has shown that science identity plays a role from school years through early career and career establishment. Moreover, identity can serve as a mitigating factor and important influence on other motivational constructs in STEM such as science self-efficacy, sense of belonging in STEM, and STEM career intent.

The Expert Panel

The expert panel represented three projects presented in the STEM for All Video Showcase, in which science identity was central to their strategies for broadening participation in STEM.

The moderator, Dr. Iris Wagstaff, currently serves as the STEM program director at AAAS, and has led efforts to broaden participation in STEM at the K through 20 level, both in formal and informal settings. She serves as the PI or Co-PI on five NSF-funded grants. The panelists included Dr. Gabriele Haynes, founder of Haynes Evaluation and a senior associate at Kate Winter Evaluation. She, and Dr. Wagstaff were both engaged in the project Preparing Diverse STEM Researchers to Address Global Challenges and brought insights from the project's Emerging Researchers National Conference. Dr. Daniel McGarvey, a freshwater ecologist and director of the graduate program in the Center for Environmental Studies at the Virginia Commonwealth University, spoke about a project called Emerge: Broadening Participation in Leadership in Freshwater Science. Dr. Preeti Gupta, who serves as a senior director for children, family, and youth programs and research at the American Museum of Natural History and spoke about her project video Staying in Science: Investigating STEM Persistence in High School Youth which shares a longitudinal study of youth who participated in an out-of-school in-depth science research and mentoring program through New York City's Research Mentoring Consortium. (*See full panelist bios*.)

Three Projects and Their Strategies

The webinar began with the panelists briefly describing their projects work in relation to STEM identity as a strategy for broadening participation.

Daniel McGarvey introduced the "Emerge" project and explained that it is a series of five annual activities in which participants engage. Each of the activities essentially maps to some part of science identity and by reinforcing these concepts, we increase confidence and a sense of self-awareness in underrepresented individuals in STEM. The activities engage students with freshwater science, help support the building of their science (self) identity through research during the year, build their capacity

in the analysis and presentation of data, and build their peer and mentor network within the field, in the context of both field research and professional conferences. Participants attend an annual meeting of the Society for Freshwater Science which introduces them to current research and researchers and strengthens their understanding of how the community of practice works — how research is presented and critiqued, and how collaborations can take shape.

> *Our hope for the meeting is always that if you think back to what your first big professional conference was, it was kind of a nauseating experience for most of us. It was very nervous, particularly if you were not part of a big lab that sent a lot of students to that first meeting. So we try to take all that anxiety off the table. We basically want our participants to feel like they're part of the biggest, coolest group at the meeting.*

This is complemented by two workshops that offer programming skills and working with big environmental data, and graphic design.

> *These are valuable, super marketable technical skills. So we emphasize crash courses in those with the hope that people will feel really empowered, if they're applying to graduate programs or applying to a first job, that they have something that they think is going to be really attractive and highly marketable.*

Preeti Gupta described the Staying in Science project. This 10-year longitudinal study is tracking 358 young people examining how their sense of self and connections to science evolve as they learn to do science, engage in the practices of science. A high proportion of these students (75%) expressed an intent to major in science, and the study is examining how their science identity and intentions develop over time, as the move through school into college and into the workforce, as they negotiate the challenges, such as microaggressions, the changes in school culture and expectations, and more, along their trajectories.

> *By doing science research, you're learning the practice in science, and that's something that we track over all these years. The other thing is the network building. How do you surround yourself with people who can become significantly important for you, peers and adults of all types? ...Colleges can be places where they experience microaggressions, where they experience obstacles and but also can have a lot of resources to support them. So we want to understand that complexity as we look for their trajectories in STEM and STEM adjacent fields*

Gabriele Haynes spoke about the Emerging Researchers National Conference, which has now occurred for more than 10 years. The conference brings together historically underrepresented students, racial and ethnic minorities, women, first generation students, students from minority serving institutions and students with disabilities at both the undergraduate and graduate level. Participants are given the opportunity to present their research through posters presentations, and through oral presentations.

> *They are exposed to the experience of having their work being presented to judges and winning awards, and all of the other things that happen at a conference that would normally be a source of anxiety or nerves for students just entering the academic world. They get exposure to all of that before they've entered into STEM careers. They get to attend workshops. There's a career development fair, they get to learn about internships and grad school opportunities. Most importantly, to see role models that look like themselves doing really big important things in STEM. Data is collected measuring science identity, self-efficacy in STEM, sense of belonging and desire to persist, that is, whether or not they feel like they're going to continue in STEM.*

Challenges and Barriers

The panelists were asked about the challenges faced by their projects. All the panelists stressed that the hardest challenges young people face in entering and staying in STEM are not financial, but rather human and sociological. Critical barriers are encountered at transition points, for example the transition from high school to college, and from college to the early phases of a STEM career.

At these points, students whose science identity is still tentative and in formation can be discouraged by messages that they do not belong, or do not have the capacity to succeed. Preeti described how in the transition from high school to college, students can find even the logistics of negotiating a large new campus difficult to overcome (such barriers can be encountered even in the transition from middle to high school Falk and Drayton 1998). Even after such initial barriers are overcome, students can still doubt that they legitimately belong to the new culture they are entering: "At that first transition point, we know the imposter syndrome, is and remains a big thing."

Even if this anxiety is allayed in the course of their experience (perhaps by participating in a project such as those described here, or by other high-impact practices), the imposter syndrome can return with discouraging effect. Micro-aggressions, which are almost ubiquitous, can occasion such self-doubt, and damage a science identity still in formation. As Preeti said,

> *A person can experience things that make that imposter syndrome subside, but it's there and it can come back up given vulnerable situations. As you're in college and then into the workforce, microaggression... really is so inside all the different aspects of work. And when you have these microaggression experiences, do these young people have resources and safe spaces and affinity spaces and ways to work through these aggressions? And that's when imposter syndrome comes back up, too.*

In addition, academic preparation, in terms of knowledge and technical skill, does not necessarily prepare a young person for core cultural practices of science, such as writing, presenting, and defending work at professional conferences, where critical discourse is essential to science's method of generating and testing knowledge. This "contentious practice" (Holland and Lave 2009) can be very discouraging for newcomers to the culture. To this point, Daniel said,

> *if you want to have a long-term career in science, eventually you're going to have to be an author on some sort of technical publication that probably is going to get chewed up at somewhere in the process. And thinking about how I reacted many years ago to that the first few times, and yes, I've gotten a thick skin to it now, but what is somebody who's young who just submitted the first paper, or who's a person of color, going to think when they get these really unkind remarks back? They seem unfair. They seem un-objective. And I would try and counsel them actually, that is a part of science. We all kind of take our bruises there at some point, but it's not going to feel that way to you.*

Such challenges can be addressed in the course of a program like those described in this webinar, but participation leads to another transition at which barriers are encountered. It is at this point that the institutional cultures in professional societies, institutions of higher education, and funding agencies may be decisive in the success, and the flourishing, of young scientists. Even if participants have come to see themselves as authentically "belonging" in their discipline, institutional cultures can present strong contradictory messages. Therefore, the component of science identity that relates to others' view of the new scientist as belonging or not belonging in science in many cases remains to be addressed and transformed, even when there are programs, supports, and opportunities that help young people come to see themselves as scientists.

Daniel said,

> *It was easy enough to create a really enriching, exciting and inclusive experience for the year that participants were in the program. But we are scratching our heads trying to figure out what's the best way to offer them continuity as they exit the program.... We want to make freshwater science as a discipline more diverse and I do think we're on a good track for that. But I think a lot of people would say that there is that hard transition once you get out of college, once you get out of graduate school.*

Best Practices

Panelists noted that "success" in STEM can include various measures. Simple persistence in the field is one important indicator, but attention should also be given to the sense of well-being, of flourishing, in one's chosen career. This is an important matter to attend to as students are developing science identities. As Iris said, "personally from my mentees, just the emotional health and wellbeing. Students are struggling pre-pandemic, post pandemic, during pandemic. Students are really, really struggling. And so what we're doing [in our project] is addressing mental health and wellbeing for students in STEM."

Our experts mentioned several specific strategies to address the barriers they have seen (and often encountered themselves). First, it can be difficult for students who are attracted to STEM work to find their way into the kind of STEM career that they might flourish in. There is a wide range of ways to do STEM work, and the practicalities of learning about potential jobs, pathways to prepare for them, potential salaries, and so forth. Even when mentoring and guidance in this area are available, research suggests that it is not supportive and effective for many students from under-represented groups.

Attention to social networks is another strategy that all our panelists spoke to. Though many of these young people have supportive family and other connections, but may not have role models, mentors, or extensive peer networks within their chosen field, who can help them make sense of their experience, find their way to resources and opportunities such as internships or jobs.

As mentioned already, a key strategy for building science identity is experience in doing science. This has benefits that touch on both aspects of science identity as discussed in this webinar. By doing science, the young person sees themselves enacting their science identity, but they also begin to build a social network within the context of that science. Holland et al. (1998) spoke of individuals in a culture as living in a "figured world," in which their actions, their knowing and sense-making, and social relations are shaped in accordance with their identity, and in turn make the resources of the culture available to the individual. Participation in undergraduate research (for example) enables the development of rich resources that support the student's inhabiting their science identity, and flourishing within the field. Moreover, it has synergistic effects with other "high impact practices" (Kuh 2008) for supporting STEM students from under-represented populations.

Gabriele said,

> *I see a lot of success with undergraduate research...with a faculty mentor or a near peer mentor or some sort of collaborative learning strategy where research improves a student's identity as a scientist. Because it's one thing to sit in the classroom and learn, but it's another thing to do science and then to go and show it to someone. On every level it makes students able to see themselves having a future in science. And it brings the idea of science as a job into their minds when it might not have been before because they are suddenly taking these principles, they're learning in the classroom and applying them to real world problems.*
>
> *And I think in that way, undergraduate research and also graduate research, but just research in general is one of the best ways to reduce some of these barriers. Because it opens the door for*

the other high impact practices that I see working, which are collaborative learning, peer mentoring, academic advising, being around role models that where they can see themselves in the people in leadership roles.

However, the panelists observed that many of these strategies are aimed at intervening with students, while not addressing systemic issues that may interfere with the development of individuals' science identities, and their ability to live them out in their work life. Thus, as Gabriele said, these interventions have been known to have positive impacts on individuals for 20 years or more, but they have not been institutionalized nor generalized within the STEM fields. Preeti added that, because of this lack of institutionalization,

I don't think we have effective practices actually. I think that we as a group of people who care about this are in the minority maybe. And we have to maybe come up with practices to talk to our peers first and do that systemic change work because the effective practices that we've been doing with young people...do work, but they do not work enough and for enough people.

Conclusions

Iris in alluding to her own experience as she reflected on Preeti's comments on social capital and the need to address systemic issues, said:

You touched on the social networks and the social capital. I have personal experience with that. I always credit my mom. I came from a low income, single parent, divorced mom background and I always say she never knew a Black scientist, but she created one. But that was with the help and support of a village that included amazing K-12 teachers ,some that I still work with today, from my hometown of Goldboro, North Carolina.

You also mentioned the microaggressions are real. I've experienced that through every stage of undergraduate and graduate school and even into my professional life. And then you also mentioned the need for systemic and institutional change and that is the biggest and hardest area to implement the theory of change, just changing people's thought processes and mindsets. There are some ways to incentivize that, for example, with broader impacts with the National Science Foundation.

Formation of science identity has two parts. First there is the individual's sense of themselves as a scientist — someone who is actively interested, feels that they are able to act on that interest, and that they want it to be a core part of their life and work in some fashion. Our panelists all emphasized that much of this can be supported or stimulated by *doing the science* — you learn the content and skills, and you have concrete evidence that you *can* do it because you *are* doing it. Doing the science also can help the individual enlist mentors and peer collaborators and this in turn can help builds networks of people with shared or cognate experience, a long-term resource for persistence and flourishing, especially in the face of institutional barriers and microaggressions. Thus, the combination of an increased sense of competence with some community support can help provide resilience in the face of barriers, and persistence in finding one's place in one's chosen field.

Preeti reported from her research that the climate of respect within a school, campus, and department can play a significant role in encouraging young people to continue along a STEM track: "We found that that high levels of acceptance is associated with fewer microaggressions." Moreover, the more students feel they are accepted in their school or major department, the more this reinforces their sense that they belong in their field.

All the panelists agreed that the kinds of personal support one might get from family and friends is important, but not sufficient for the development of a robust science identity, robust enough to support the individual's feeling free to choose a life in STEM for themselves. This is why institutional change is critical, because despite the successes reported by projects such as those reported on, and others supported by agencies like the National Science Foundation or NASA, these have limited scope and limited duration of funding. Many young people are still not benefiting from the insights of research on science identity, at a time when broadening participation in STEM fields is clearly a central ingredient not only for the flourishing of the young people drawn to those fields, but for the future flourishing of our society.

Recommendations for Researchers

These projects are themselves research projects, collecting data on participants' science identity and related impacts of the interventions. All the experts, however, pointed to the importance of understanding the institutional context surrounding the effective practices being implemented. Researchers would contribute considerably to the broader impact of these and similar interventions related to science identity by examining projects and their extent (in time and across settings) within a taxonomy of "scale" proposed by Cynthia Coburn (2003), which includes an increase in numbers of users, of ownership, of persistence of use, and of ownership by teachers. Case-study examinations of projects aimed at broadening participation through science identity work within some such framework would contribute considerably to build theory about promoters and inhibitors of this general strategy. This in turn could provide a solid basis upon which to develop an examination of the issues and dynamics related to systemic change needed to support the practices that promote science identity and self-efficacy in youth from populations currently under-represented in STEM fields. One might say as well that such a theoretical base could allow a study of the phenomena of resistance to change in this area.

Recommendations for Administrators, Teacher Leaders, and Policymakers

During the webinar, Iris asked, "What should we be advising institutional leaders? What can be done at the institutional level?" A first recommendation would be that these leaders should undertake to read some of the relevant literature on the topic of STEM identity (the blog and references from this Theme of the Month would be a place to start).

On the basis of some shared knowledge about the issues, administrators, teacher leaders, and policy makers could initiate reviews of such practices of course design, funding decisions, mentorship within STEM disciplines, collaborative research opportunities, and academic guidance with a particular attention to potential STEM students from under-represented groups.
Given the emphasis that the expert panel placed upon the importance of students doing science, academic leaders (including funders) should also be examining in what ways they can create opportunities for student research with skilled mentors. While in some institutions the existing faculty may have the experience and pedagogical skill to participate in such student research, for high schools and perhaps some IHEs this shift in emphasis will best be accomplished by collaboration or partnership with researchers (citizen science projects, now very widespread) can in some cases provide the foundation for such collaborations).

Like all partnerships, these will rise or fall on the quality of communication among the partners about intents, expectations, distribution of resources, trouble-shooting mechanisms, and periodic review of efforts to date. The emphasis of such reviews should be at least four-fold: [a] quality of program design and implementation, [b] impacts on focus population of students (positive and negative), and [c] benefits and drawbacks for scientists or other STEM professionals participating; [d] institutional role in

promoting or inhibiting the intervention. A design-based research approach might be very useful and yield useful contributions to the research literature.

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