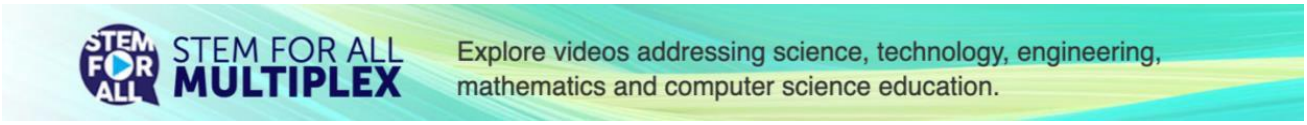

Developing Youth STEM Change Makers
STEM for All Multiplex Synthesis: March 2023

Adolescence has long been understood as a critical period for students' developing sense of self-efficacy in STEM, and their interest in learning and doing science (Kim et al 2018). Research suggests that teenagers gain motivation in education when their agency is supported and respected, and they feel they can have a positive impact on issues that matter to them (Snow and Dibner 2016, Broadbent 2011). Students are more likely to engage in and study STEM with enthusiasm when given such opportunities (Drayton and Puttick 2018, Puttick and Drayton 2017).

The Expert Panel

The March Theme of the Month focused on "students as STEM change makers" and our expert panel presented insights from projects in which students' interests and action were the driving force in the work. Our moderator was Jim Callahan, director of Mobile Climate Science Labs and co-founder of ClimateChangeEducation.org. Jim was joined by three panelists as well as two student leaders. The panelists included Kelly Greene, from the International Chief Science Officers (CSO) program. She is the Chief Operating Officer of SciTech Institute, the statewide STEM Learning Ecosystem for Arizona. Kevin Cuff directs the East Bay Academy for Young Scientists (EBAYS), a program, at University of California Berkeley, Lawrence Hall of Science. Mike Barnett, a Professor of Science Education and Technology in the Lynch School of Education and Human Development at Boston College, spoke about the Change Makers: Urban Youth Food Justice Ambassadors project. The two students who joined the panel were Antonia who is involved in several of the projects with Jim Callahan, and Sahiba who is a student ambassador in the International Chief Science Officers (CSO) program. (See full panelist bios.) The moderator and panelists have videos sharing their project work in this month's playlist.

Jim Callahan introduced the webinar with a series of questions, that can serve to propel future efforts in student and community inquiry and transformation. He asks:

> *What happens when young people are not simply learners of STEM? Its facts, its methods, its careers, its challenges. What happens when young people are engaged? What happens when they are able to pursue and act on the subjects and societal challenges that they find most important? What happens when young people actually are using STEM to change society now, not 5, 10 or 15 years in the future? What happens when young people actually change STEM itself while they are young people?*

Student Engagement

The panelists and student leaders proceeded to briefly describe their projects and the ways that students were engaged in each. Students were involved as STEM change makers in a variety of ways.

Students conducting research. Kevin Cuff spoke how in The EBAYS project, students were engaged students in community-based research on environmental science including investigating air, water, and soil quality which are key factors in public health and well-being. Using professional equipment, students analyze samples, evaluate the results, and present the results — and their implications — in public forums.

The project has so far collected more than 2500 soil samples for lead levels (highly correlated with lead levels in human residents). The issue of lead contamination has additional dimensions, since (as with so many environmental problems) the impacts are greater in lower-resourced communities— with high proportions of working-class people, and people of color. The students are recruited through, and connected with, grassroots organizations engaged in social change efforts, which means that the science they are learning and doing is authentically rooted, and the community is directly interested in their research. Seeing science as a tool to address social issues increases students' engagement and sense of self-efficacy in science practice.

Urban food ambassadors. Mike Barnett talked about the Boston College program in which students become "food justice leaders," designing, building, and disseminating systems for addressing food injustice and inequality, as evidenced, for example, by "food deserts," - areas in which stores carrying good quality food are sparse or nonexistent, thus presenting significant practical barriers to good nutrition. Participating students explore a range of solutions to such problems, including building and studying model systems for local food production, often using innovative technology. A key element of this work is that the youth assume roles as leaders, mentors, and teachers for younger peers. In the course of their participation, the students experience science as useful and applicable to social justice issues, and they also come to experience themselves as contributing to others' learning and empowerment. This experience, in which STEM serves a real-world purpose, can re-open a path into STEM for young people who have before then opted out of science.

Chief Science Officers. Kelly Greene and her student colleague, Sahiba, described the International Chief Science Officers (CSO) program, through which young people, nominated by their peers for the program, learn to be advocates for STEM in their schools and communities. As Sahiba explained, the program has four core values:

1. To create networks of CSOs for the purpose of sharing information and opportunities about STEM learning and careers. After eight years, the program now has a growing number of "alumni," CSOs who are now in college or beyond who share opportunities with current CSOs.
2. To use those networks to foster communication and collaboration among the CSOs, encouraging each other's growth as STEM advocates and as people. Sahiba relayed:

   Just a couple of years ago, I was terrified of failure and I was stuck in a bubble of the introverted, so I was very shy. But the encouragement from my CSO peers helped me to adapt myself, and in certain scenarios, I became an extrovert where I can actually use communication and leadership in a good way.

3. To enrich the STEM cultures of schools and communities, through student-developed action plans. Sahiba offers an example of her action plans:

   My personal action plan has been a math festival...The goal is to just gamify math in a way that's actually fun and promotes problem solving because everyone kind of has that internal fear of math. But I think that anyone can do it if they get to actually experience it in a fun way and have that opportunity to let go of that fear and see the problem-solving aspect of it rather than just like the formulas. So, I always did these on Zoom, but...I've tried to implement these in person and just recently I did some for a STEM club at my middle school.

4. To amplify students' voice in community and policy decisions in which STEM is an important element.

Education and advocacy. Our second student leader, Antonia, elucidated the roles that students were taking in projects that she is engaged with (in which she is a colleague of Jim Callahan). She spoke of multi-generational programs which engaged in education and advocacy around greenhouse-gas mitigation, energy efficiency, and climate change, and provided resources to support educators and activists: Climate Club, Mobile Climate Labs, and the Clean Network. Their work emphasizes diversity, equity, and inclusion, as well as other aspects of social justice, since all of these social factors need to be taken into account when addressing the effects of climate change. Antonia briefly mentioned several recent activities to give a concrete picture of the many-sided nature of their work in education and public policy:

> *Examples of our work… include advising Smithsonian museum directors on energy efficiency improvements in their human origins exhibit and meeting with high school environmental action teams in Florida. On Saturdays we provide hands-on labs to 15,000 family members in California's wine country at one of the Bay Area's 10 mass-scale hands-on STEM festivals where we are prominent, very popular exhibitors. As one member of my team, I have given STEM presentations personally on the floor of the Smithsonian National Museum of Natural History to families across the U.S., TED-X Talks, Virtual Youth summits across the U.S., to K to 12 schools, and webinars and conferences hosted by federal agencies.*

Successes and Challenges

All the panelists agreed that these projects and other provide powerful evidence (from around the world) that social justice is a way to get (re)engaged with STEM, and to stay engaged. Students help conceptualize and design projects, and this agency encourages deep learning and commitment to the quality of the work, rooted authentically in community life. As Mike said,

> *One of the biggest successes is the recognition in the youth that social justice is the way to reengage with STEM. And the surprising fact that through that hook, that is what maintains their interest and engagement with science over time.*

Even so, panelists described how such programs can encounter significant challenges. For example, some of the issues that students have addressed are controversial in some communities. Policy makers often dismiss students' voices, or not take them seriously, even when they are bringing solid data to bear on the issues they've been investigating. As a result, sometimes the research does not result in anticipated changes in policy, which can be discouraging for the students. Kevin provided an example from EBAYS's soil lead survey:

> *We have quite a few samples from throughout the city. We've seen that much of the contamination exists in communities of color or low resourced communities. As a result of that, we've had students make presentations that included city and council, city, and county officials. And unfortunately, although they have done these presentations and many council members for instance in Oakland have experienced numerous presentations at which we present to them the evidence that students have generated, there has been no action on the part of the city and county officials.*

Such a challenge requires the development of alternative strategies by which youth scientists and advocates can overcome officials' disinclination to take the students' work seriously. In this connection, Kelly tells student not to give up but to find a way around adult barriers. Along these lines, Kevin added:

> *One way that we've discussed perhaps overcoming this challenge is by finding or identifying one particular council member or one particular policy maker who can then act as our champion, who can do the behind-the-scenes sort of things that these sorts of politicians and policy makers do all the time.*

Students have learned that change is not always easy and requires persistence and perseverance.

Evidence of Impact

Jim asked the panelists if they had collected formal evidence of impact. Panelists reported both qualitative and quantitative evidence related to increased self-identity with STEM, an increased sense of the value of STEM as a tool for social justice, and an increased comfort with STEM subject matter.

Kevin reported such gains across all genders, ages, and ethnicities among EBAYS participants. EBAYS found that projects in which students engage with science for social change, enables their communities to realize that the students have STEM capacity that they didn't recognize before. Parents and community members begin to value this expertise more.

Mike reported on data collected on participating students who began the program in middle school with the Food Justice Ambassadors program. He found that out of 1200 college graduates, 70% majored in STEM in college — evidence of strong personal investment and STEM self-identity. This is all the more telling since when many of these students entered the program, they had low interest in science. He also recounted findings from a recent paper (Konowitz et al. 2023) which showed that mothers helped their adolescents to develop their sense of purpose by serving as a source of inspiration and providing support. This in turn sparked a desire for the adolescents to make their mothers proud and opened up conversations between mothers and their adolescent children about their future paths.

Kelly reported on the trajectory of student growth over time among the Chief Science Officers. Students grew in their STEM knowledge, but also in such skills as teamwork and collaboration and public speaking. Kelly also reflected on how the CSO program itself has grown, reaching beyond schools to involve new CSOs from to community centers, boys' girls' clubs, online schools, and more.

Recommendations for Researchers

The expert panel raised several areas for future research. More needs to be learned about effects in the community that result from student STEM leadership, and the ways that community needs and interests can drive student learning. It is possible, also, that as communities engage with such student-driven inquiry for social change, that the communities themselves increase their capacity for STEM inquiry in their own behalf, understanding their funds of knowledge (González et al. 2005) as valuable assets in such inquiry. How can research on scaling as persistence and ownership of change (Coburn 2003), and on community education (Bruce 2022) inform and be extended by student-led STEM for social change?

The panelists also noted the divide that seems to exist between STEM education researchers and the field itself and teachers. How can that gap be bridged in the context of student-driven STEM? How do teachers change their practice so that their particular skills support their students, support the communities, and enrich their own learning in the context of STEM for social change?

Recommendations for Teacher Leaders and Administrators

Teacher leaders and administrators can play important roles in exploring student-driven STEM projects for social change, first by participating in pilot projects in their school, and by taking a lead in studying such efforts. Careful and reflective studies will attend to the way a project arose, the roles of various participants (students, faculty, administration, parents, community, etc.), what the original intentions were, what resources were needed, how the objectives may have changed, what knowledge the students needed to learn, and the points of view and critiques of all parties. Such a study would be of great value for the school as it seeks to learn about student-driven STEM for community change. The literature on community schooling (Bruce 2022 is a good recent reference) may be of particular value.

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