BOARD # 457: Student Interest in STEM Careers: An NSF ITEST Project for High Schoolers' Renewable Energy Technology Engagement

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This NSF ITEST project (Award # 2148429) at Illinois State University focuses on engaging students in four Chicago Public High Schools in an afterschool STEM program, SUPERCHARGE, where they experience hands on activities with renewable energy technologies and related sustainability-tied experiences. Using micro:bit and kit materials, students code, build, and investigate technologies to explore phenomena like air quality, and the modeling of technologies like electric cars and environmentally responsive homes. The communities in which the schools are set are Communities of Color that have historically been positioned in the media through a deficit lens but have rich cultural and economic assets. This project aimed to develop an afterschool program that related to those community assets with the goal of fostering a sense among students that they belong in STEM and that STEM interests and career paths were available to them. All students in the district take an introductory computer science course during their first year of high school, and we leveraged that asset too through the incorporation of block coding in most activities. This blending of basic coding skills and the application of those skills to renewable energy related problems and phenomena also made the program accessible to students and reflective of some knowledge and skills they had already developed.

The design of the curriculum and program was influenced by Bronfenbrenner's Ecological Systems Theory [1]. Darling [2] describes three domains of this theory, one of which directly underlies our work. "[D]ifferent environments will have different affordances and will be responded to in different ways by different individuals…one will find ecological niches in which distinct processes and outcomes will be observed" (p. 204). Every student is unique, but they share a community which has STEM affordances that the program leveraged. The processes and outcomes we aim to observe include *belonging* in STEM among participants in the afterschool program. Belonging is described by El Halwany and Adams [3] as a process. It is a dynamic interaction between an individual's internal emotional landscape as it is negotiated with external, social landscapes. They describe a "processual character of belonging…[arising from] attending to students' affects, desires and emotions…continuous, ambivalent movements between attachment and detachment to STEM" (p. 4). Students engaged with belonging in all SUPERCHARGE activities in the sense that they had opportunities to experience connection and interest. By involving undergraduate majors in STEM we aimed to model, and be informed by, the unique ways that students of different backgrounds experienced belonging in STEM in ways that fostered a decision to pursue a career in STEM. Across academic year club meetings, multi-school workshops, and a summer program our goal was for that experience of belonging in STEM to develop. One layer of this aim was to foster interest in STEM careers.

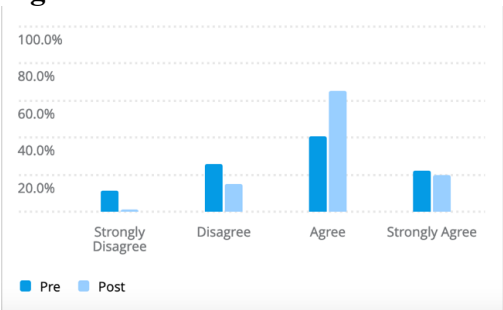
Between 10 and 20 students met weekly afterschool during the first year of implementation which was preceded by a planning year in which teachers provided feedback on activities and connections to the communities of the schools were developed. Four faculty were involved in the design of the project and activities and an additional group of undergraduate STEM majors were also involved in the design and pilot of all activities. Four goals frame this project and research. These are to learn how (1) high school students' knowledge of STEM careers and STEM domains change across their participation; (2) the high school students improve their interest in

STEM career attainment and their self-efficacy for career relevant skills; (3) the undergraduate STEM majors' views about Communities of Learners of Underrepresented Discoverers develop across their participation; and (4) teachers' knowledge of current STEM domains, skills, and careers change. To examine the impact of the programming on each stakeholder group, PEAR's CIS-S and CIS-E surveys, interviews, activity surveys, and workshop surveys were used. Currently, the data from the first year of programming includes 21 pre-post student surveys and 10 surveys from the undergraduate designers and 9 surveys from the teachers in the program. At this time, statistical tests were not appropriate due to these small numbers, but future years will bolster these numbers, and we anticipate the ability to perform statistical tests as the data set grows. Therefore, we focus on a qualitative analysis of the surveys and interviews at this stage.

How do high school students' knowledge of STEM careers and STEM domains change across their participation?

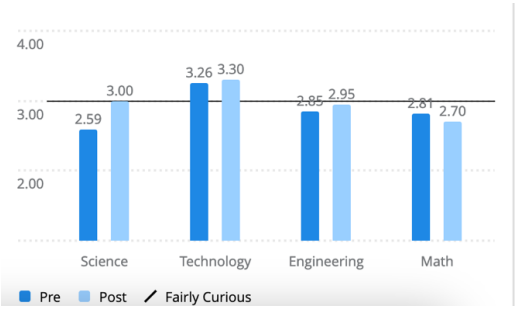
Goal one focused on how high school students' knowledge of STEM careers and domain interest changes across program participation. Research across the first year of implementation revealed improvements in participating students' interest in a career in STEM in their future, their curiosity about STEM domains (with the exception of mathematics), and their attitudes toward STEM. Their interest in a career in STEM in their future underwent change most notably in the *agree* category as shown in Figure 1.

Figure 1 ***I want a STEM Job in the Future***



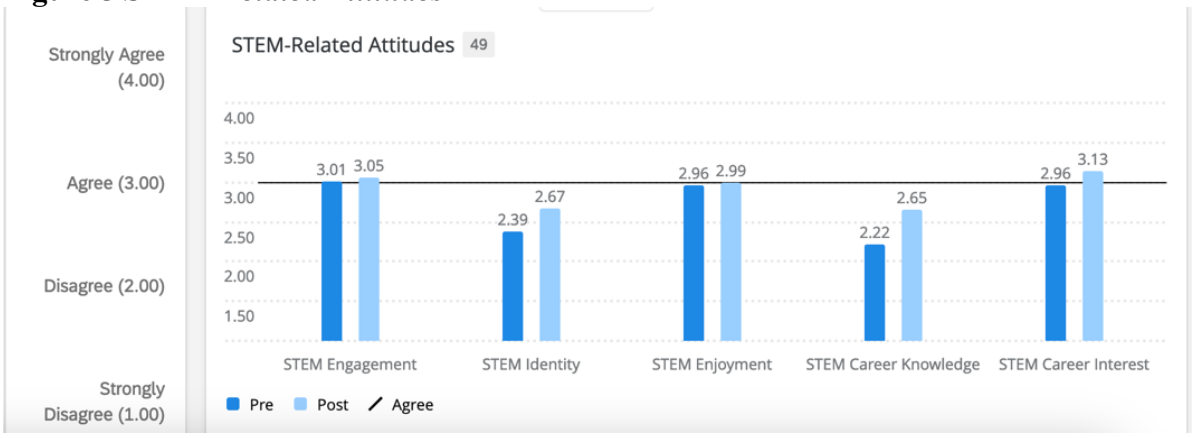
High school participants curiosity about STEM domains also showed modest improvement across participation. Mathematics is a notable exception, however. Programming did not explicitly include mathematics though students engaged in coding activities and underlying mathematics skills were important to those activities. Figure 2 illustrates the pre and post self-ratings in each STEM domain.

Figure 2 ***Curiosity Toward STEM Domains***



Students' attitudes toward STEM also showed an overall improvement. Their engagement, enjoyment, identity, career knowledge and interest each improved pre to post participation. While improvement in their engagement and enjoyment of STEM was modest and was strong at the time of the first survey, changes in their perceptions of their STEM identity and career knowledge were more pronounced.

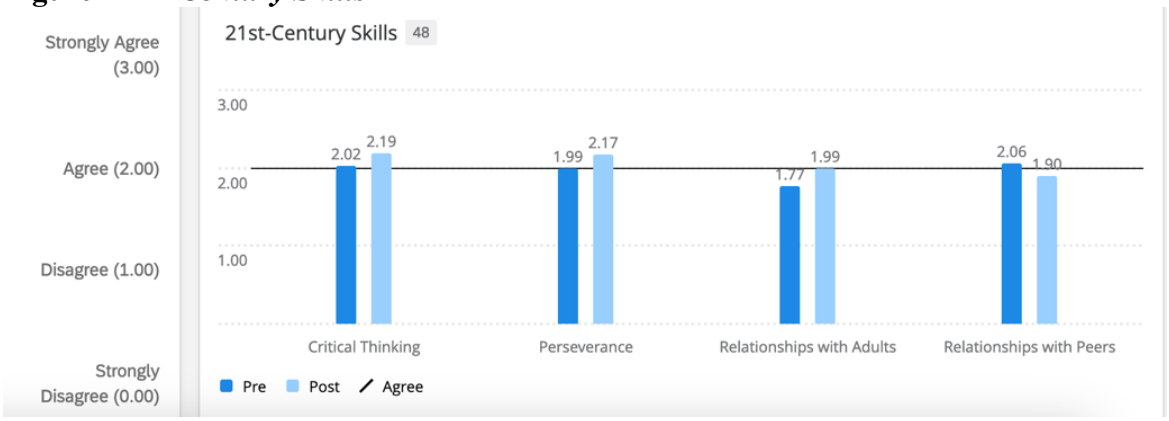
Figure 3 ***STEM Related Attitudes***



How do students' interest in STEM career attainment and their self-efficacy for career relevant skills change across their participation?

While students' interest in STEM career attainment improved, their self-efficacy for career relevant skills were mixed. The trend is positive overall, but interestingly the 21st century skills tied to work with peers showed a modest decline.

Figure 4 ***21st Century Skills***

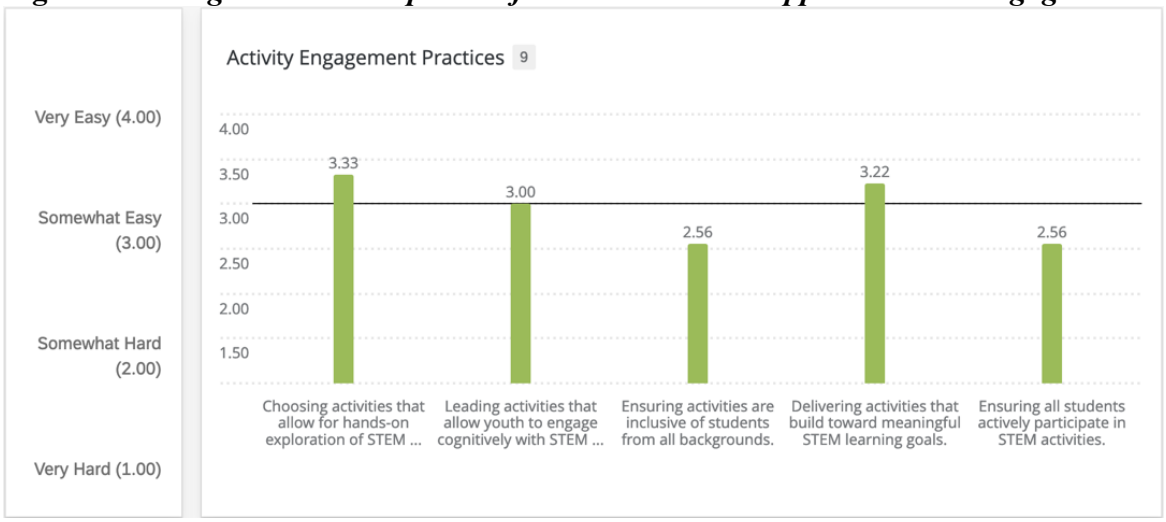


STEM majors' views about Support for Communities of Learners of Underrepresented Discoverers

Across their participation, interviews and CIS-E data demonstrated undergraduate STEM majors' persistence in valuing the opportunity for access to STEM among high school students. Their

perceptions of their abilities to support the high school students in specific ways is illustrated in Figure 5. The interactions among the undergraduate students and high school students were specifically valued in influencing some shifts in their views. For example, student workers described in interviews how their knowledge about the students based on their interactions was informing new ideas about how to better support students.

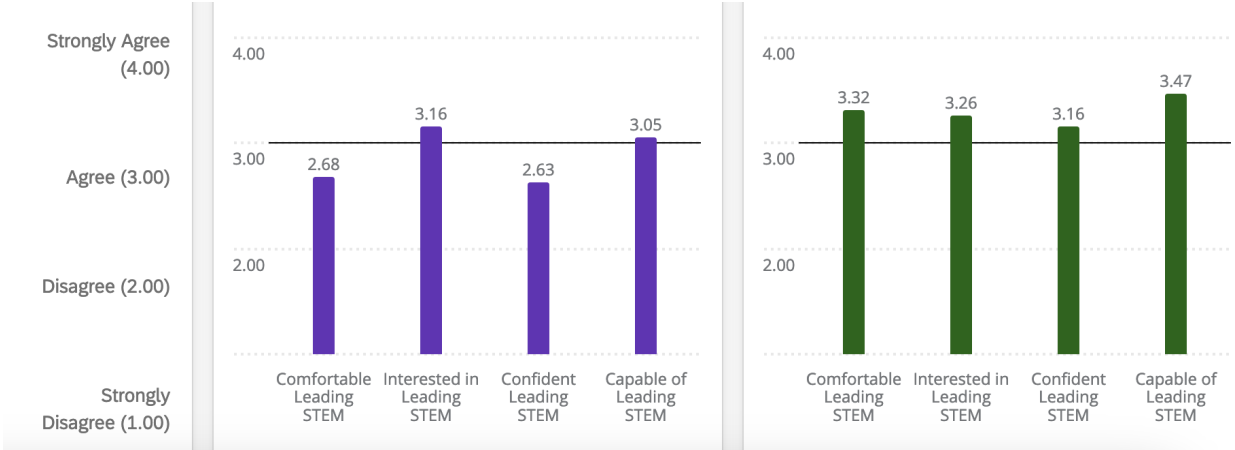
Figure 5 ***Undergraduate Perceptions of their Abilities to Support Student Engagement***



What is teachers' knowledge of current STEM domains, skills, and careers after implementing programming?

Among the teachers leading the afterschool club, their comfort, confidence, and self-efficacy around STEM and leading STEM activities improved after implementing the first year of the club. Their interest in leading STEM remained constant (see figure 5).

Figure 5 ***Time Points One and Two Comfort, Confidence, and Self-Efficacy for STEM Program Leadership***



Discussion and Conclusions

Formal and informal STEM learning spaces are important to adolescent access to STEM career pathways but this project and analysis takes into account the caution expressed by researchers in this area. SUPERCHARGE aims to bolster students' belonging in STEM and skills related to green energy, energy technologies, and related STEM areas. However, El Halwany and Adams [3] emphasize that

> desires for a diverse and inclusive STEM workforce … can support the appearances of belonging and "inclusion" for different social groups, [but they] have generally fallen short of disrupting systemic inequities in science learning spaces …because the focus has been on "fixing students" rather than "fixing institutions" (p. 3).

This program attempts neither of these but instead endeavors to connect students to the STEM in their worlds as it exists using some of the skills they have already developed. By connecting renewable energy technology and engagement with those skills SUPERCHARGE expands their understanding of what STEM is and what kinds of problems it can solve. The most evident finding thus far is that participation in SUPERCHARGE shift an interest in STEM careers for students. At the time of the pre-survey, 60% of students expressed interest in future STEM careers. This may reflect some self-selection in those who participated in the club. At the time of the post-survey that number grew to more than 80% and supports the assertion that opportunities for students to engage with STEM that relates to their communities but extends their opportunities to learn with contemporary technologies is a valuable strategy.

References

[1] Bronfenbrenner, U. (1979). The Ecology of Human Development: Experiments by Nature and Design. Harvard University Press.
[2] Darling, Nancy. 2007. "Ecological systems theory: The person in the center of the circles." Research in Human Development (4, 3-4) 203-217. https://doi.org/10.1080/15427600701663023
[3] El Halwany, Sarah, and Jennifer D. Adams. 2025. "Affective Politics of Belonging to STEM: Some Conceptual and Methodological Considerations." Science Education. https://doi.org/10.1002/sce.21951