

**Beyond engineering: A networked improvement community combining
STEM equity and access with engineering content knowledge**

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Abstract

Catalyzing Inclusive STEM Experiences All Year Round (CISTEME365) is a multi-pronged project designed to increase students' interests and drive toward pursuing STEM majors and careers long-term. We provided middle/high school educators professional development training on STEM content, careers, access, and inclusion to establish out-of-school time STEM clubs for students. We investigated how CISTEME365's professional development influenced the knowledge, attitudes, and behaviors of participating educators and their practices in increasing STEM access and persistence of students within their school settings. School educators reported positive experiences with our multi-layered, integrated STEM-equity, and engineering-curriculum content. This study demonstrated the significance of offering professional development through a networked community of school educators to influence K-12 URSSs' awareness, interests, and persistence onto the STEM workforce. This material is based upon work supported by the National Science Foundation under Grant No. 1850398.

Objectives

Many research studies note the socioeconomic, racialized, and gendered disparities within a variety of STEM fields (Eagan et al., 2013). Specifically, first-generation, low-income Black, Latino, American Indians or Alaska Natives, and woman persons constitute historically URSSs in the U.S. For example, in 2016, women were awarded just 25 percent of undergraduate engineering degrees (National Center for Science and Engineering Statistics, 2019; *U.S. Census Bureau QuickFacts*, 2019). Among underrepresented racialized minorities, Latinx populations received 10 percent of all Bachelor's degrees conferred in engineering, while Black people received 4 percent (compared to 19% and 13% of the population respectively). It is crucial for educators and policymakers to offer interventions that increase the participation of URSSs, especially in the engineering fields.

School educators, especially guidance counselors, serve as gatekeepers of STEM opportunities for URSSs (Schmidt et al., 2012), yet they are underutilized in STEM interventions within the K-12 schools. Counselors introduce students to different types of careers and support students in executing academic and personal planning for these different careers (American School Counselor Association, 2004). Yet, studies show that counselors have little knowledge about the array of STEM careers, especially the role of engineers and in the field of engineering overall (Cunningham, 2009; Cunningham et al., 2005). Research also shows that counselors' limited knowledge of the engineering field affects their counseling roles with students (Pollock, 2013). It is important to improve counselors' understanding of the engineering field to improve URSSs' access and persistence toward high-demand, high-wage, and high-skill job opportunities in the engineering field

This study draws from a federally-funded research project, CISTEME365. CISTEME365 a multi-year project designed to increase URSSs' interests and persistence toward pursuing STEM careers long-term. The CISTEME365 project includes the Inclusion, Diversity, Equity, and Access (IDEA) Institute, a professional development series for middle/high school teachers, counselors, and administrators to learn, discuss, and implement student-centered activities grounded in research-based STEM-equity content. For this study, we examined CISTEME365 program effects on school educators' practices on STEM IDEA. Supported by a case study design, we used single-person interviews, focus groups, and survey data to address the following research questions: (1) How do curricular interventions of STEM-equity and engineering content

offered by CISTEME365 program affect educator and counselor understanding of STEM careers and paths; and (2) affect educators' and counselors' ability in implementing practices to address STEM IDEA?

Theoretical Framework

We utilize a sociocultural perspective to inform our work. Through a sociocultural lens, Mansour (2020) notes that science education is understood as a “meaning system” with “cultural understandings, interpretations, and language of its own” (p. 193). Given the abundant racialized and gendered disparities within STEM fields, educators must pay special attention to how scientific knowledge is understood and viewed by their students. Educators risk perpetuating the existing practices that cause racialized and gendered disparities in STEM. To engage URSs in STEM, we believe that educators must meaningfully fuel their sociocultural perspectives to drive their STEM IDEA practices through an intentional networked community for professional learning.

Recent research literature on sociocultural perspectives focus heavily on only in-class teachers (Mansour, 2013, 2020), and rarely professional learning transfers across school classrooms, roles, and district boundaries (Zeichner, 2001). Because guidance counselors are vital to college/career trajectories, yet underutilized in STEM-based interventions (Cox & Lee, 2007; Griffin & Stern, 2011; Virginia Demonstration Project, 2010, 2010), we implemented a networked improvement community (NIC) model for ongoing professional learning beyond the summer institute, allowing multiple individuals and teams across roles and contexts to address a shared social problem (Bryk et al., 2011). In a NIC, the participating teams troubleshoot issues together, working collaboratively to drive their cultural competence that, in turn, influences their interactions with students. This study contributes to the growing body of research on NIC strategies in education by describing the shifts in school educators' sociocultural perspectives via this networked professional development opportunity.

Methodology

For this study, we contacted school educators from throughout the state of Illinois, serving a diverse population of 200,000 students from inner-city, rural, and/or low-income backgrounds. To enroll in our CISTEME365 program, schools must identify a three-person IDEA team of counselors, teachers, and other relevant stakeholders; provide a letter of support from a school administrator; establish (or improve) a STEM club within their school, and nominate students to participate in STEM-focused summer camps hosted by a well-known university engineering program. Each participant received a stipend plus room, board, and travel reimbursement for the 2-week IDEA Institute and completion of grant-related activities, as approved by the Institutional Review Board. Also, IDEA teams received a kit of engineering equipment for the STEM clubs and flexible spending on STEM-related equipment (e.g., 3D printer, drone building, VR headset, etc.) for the club.

Our engineering content focused on providing educators' competencies in leading informal engineering and other STEM-related activities for students. Over the summer, educators received hands-on instruction and worked with engineering professionals to learn about careers in STEM, STEM opportunities, engineering content for the STEM clubs (e.g., circuits, soldering, communication, calculators, etc.), and engineering grand challenges. Coupled with our engineering content, we delivered STEM-equity work designed by the National Alliance for

Partnerships in Equity. Specifically, we offered curriculum on research-based, strategy-driven, practical-application-focused on micro-messaging and educator self-efficacy. The curriculum provides school educators tools specific to their school needs in addition to addressing gender and culturally-based bias that can hinder URSSs' interests and pursuit of STEM fields. Educators continued to have access to these materials throughout the school year.

Because we focus on the curricular offerings of the CISTEME365 program, a case study research design offered the opportunity to review "a bounded system" with a substantial amount of data collection (Creswell, 2012, p. 465). In this study, the "case" is the STEM-equity and engineering professional development offered in the networked professional development of our CISTEME365 program. Data collection occurred from April 2019 through May 2020. We conducted single-person interviews, focus groups, and pre- and post-surveys with members of the five school teams participating during this time. Overall, more participants identified as male ($n = 7$) than female ($n = 6$). Participants reported doing education work for an average of 15 years ($SD = 9.3$), and the majority of participants reported as teachers ($n = 8$), while the remainder were counselors ($n = 2$), and other school personnel ($n = 3$). All participants earned postsecondary degrees, and participants racially identified as Native American ($n = 1$), Asian American ($n = 1$), African American ($n = 5$), and White ($n = 4$), with one of these individuals identifying as Hispanic ($n = 1$).

Participants completed pre-Institute, post-Institute, and post-program surveys that included both closed ended, scale items (i.e., Neutral/Not sure/No Impact = 0 to High Impact = 6; Strongly Disagree = 0 to Strongly Agree = 5; Not at All = 0 to Very Much = 6) and open-ended questions. These surveys assessed the impact of our programming on school educators' KAB in addressing STEM equity and educators' technical skills in engineering. To analyze scale items, we performed descriptive statistics for demographic data using R Studio (RStudio Team, 2020). To analyze responses to open-ended items, we used an inductive, open-coding approach. The pre-Institute survey ($n = 12$) was 40 questions, the post-Institute survey ($n = 11$) was 114 questions, and the post-program survey ($n = 7$) was 90 questions. To gain in-depth insight on experiences, we invited participants to join focus-group interview sessions within their school networks during the summer 2019. We developed a set of semi-structured questions to help us better understand the school culture of STEM academic advising. We then compared general themes from focus group interviews to survey responses (both closed-ended and open-ended) to gain a deeper understanding of participant experiences and for triangulation.

Findings

In this proposal, we provide an abbreviated summary of findings related to participants' discussions of curricular interventions including STEM-equity and engineering content. A more complete discussion of themes and patterns related to research questions will be offered in the final paper. While we examine these across the data collected on focus groups and pre-Institute, post-Institute, and post-program surveys with participants, we focus on the *CISTEME365 curriculum interventions* and *their impact on educator's daily practices*, using a sociocultural perspective. To maintain anonymity of participants, we modified or redacted any identifying features (e.g., personal names, school name or location).

In the post-program survey, six of seven participants indicated that CISTEME365 training introduced content interestingly and engagingly, introduced new materials never seen

before, provided relevant materials to educators, provided opportunities to practice and apply their learning, confidence to integrate CISTEME365 training as an educator, and provided useful ideas to improve educators' practices. Some educators ($n = 2$) shared about having remaining questions about the presented materials and wanting the content to be better tailored to the participants' input. Lastly, six of the seven participants indicated that CISTEME365 training would have some impact on their students. Survey respondents shared appreciation for the STEM-equity and STEM content approach offered by CISTEME365. One respondent wrote:

I really enjoyed the hands-on electrical [engineering] projects. I was very pleased with the supportive team that assisted us with every project. I do like the monthly [accountability] meetings after the summer session ...

Another respondent wrote:

I will continue to use the information and resources shared in my daily role as a counselor [and] present to teachers, staff and administrators the importance of building student's self-efficacy and how it relates to pathways to STEM careers.

Both of these survey respondents' comments highlight the design of CISTEME365 professional development training provided integrated STEM-content and STEM-equity experiences that reportedly transformed participants' STEM understanding and practices as an educator.

Participants completed focus group interviews within their school networks during the summer 2019. One interviewee shared the value of relaying *actual* STEM to students. This person stated:

[...] You hear them talk about Ebola on the radio, but you walk into a lab where they're actually studying [...] Ebola and the Zika virus [...] I want our students to understand [...] that there is a STEM approach to teaching [...]

In this response, the interviewee's experiences of hearing about STEM concepts through everyday media outlets and seeing the actual role of a STEM professional contrasts significantly. Through hands-on activities, the CISTEME365 program provided educators an opportunity to explore STEM in ways not practiced in the classroom. Another person shared:

So, educators [and] administration need to be more educated [on what STEM means]. I'm not even talking about the kids [...] We're going to do a PD with our staff when we come back. And that's going to be because I think I have a better concept of what STEM means.

This quote acknowledges the extensive learning this educator experienced within a short period, and the immediate need to share this information with other educators within their school setting. CISTEME365 collaborative approach to professional development influenced educators' interest to share their own experiences on STEM-equity and STEM-knowledge with colleagues. We argue that our multi-layered, integrative approach

affected the network of educators' content understanding, careers, paths, and equity-related to STEM, in turn, we expect rippling effects on their practices as educators and students long-term.

Conclusion and Implication

Diversifying the STEM pipeline requires novel strategies to improve the participation of URSs. With research supporting that educators have limited understanding about and experience in engineering (Cunningham, 2009; Cunningham et al., 2005), it is crucial to build educators' engineering-content expertise to support these learning outcomes for their students. By offering STEM-equity materials that supplement engineering-rich content, our work provided a professional-development network for school educators to address and implement STEM experiences for all their students. In turn, we expect these professional development experiences will impact students within these settings. Due to international and national concerns related to teacher strikes, COVID-19 pandemic, and racial issues, educators reported some unforeseeable challenges in implementing our CISTEME365 curricular materials. However, in our work, educators indicate the significance of our CISTEME365 curricular programming within their school setting. Our work promotes the importance of delivering professional development experiences rooted in STEM-equity and engineering curriculum. We assert that teaching beyond engineering is crucial to impact URSs' persistence toward engineering and other STEM-related futures.

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