Board 340: Nurturing a Community of Practice Approach Toward Equitable and Inclusive STEM Environments in Schools

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Abstract

As the Catalyzing Inclusive STEM Experiences All Year Round (CISTEME365) concludes its fifth year of implementation, this multifaceted initiative aimed at increasing access to informal, project-based engineering experiences in safe, welcoming, and inclusive environments provides us with a wealth of new lessons and questions that will provide a foundation for future endeavors. This initiative has supported 22 school-based teams of teachers, counselors, and administrators in establishing out-of-school STEM Clubs while employing strategies to create more equitable and inclusive environments for students from groups frequently underrepresented or excluded from STEM-centered activities. This paper focuses on impacts and lessons learned from a mixed-methods research study using multivariate analysis and qualitative analysis of participant interviews and focus groups, observations, and analysis of participant artifacts such as STEM Club activities and action research projects. A few key findings include instructor and student self-efficacy and knowledge of STEM college and career pathways increased, school contexts and shifts in staffing patterns impacted the sustainability of STEM Club implementation, and evidence of broader impacts was observed as teams or individuals shared CISTEME365 lessons and content with colleagues at their schools. Findings shared in the paper and poster presentation will be used to discuss how these lessons learned will be applied to future projects aimed at pre-college engineering education initiatives to broaden participation in engineering majors and careers.

Background

Historically underrepresented groups need equitable access to STEM education. Despite the increase in STEM-related careers, representation of first-generation, low-income, women, Black, and Latinx students and engineers remains significantly low [1, 2] . This CISTEME365 NSF I-TEST Strategies initiative seeks to improve the rates of female, minority, and/or low-income students entering STEM majors and careers. Over the past five years, we have been building a network of school-based teams called IDEA (Inclusion, Diversity, Equity, and Access) teams, made up of teachers, counselors, and administrators, who share a common focus of addressing STEM inequities at the school level. Key components of this initiative include year-round professional development focused on creating equitable and inclusive STEM advising and learning environments through non-competitive STEM clubs, access to materials and training in project-based electrical and computer engineering activities for the STEM clubs, and student

scholarships to attend STEM summer camps on campus at the University of Illinois Urbana-Champaign.

To date, this initiative has supported 22 school- or district-based IDEA Teams with representation from middle schools (N=7), high schools (N=15), and community colleges (N=2) in the state of Illinois (Note that two district-based IDEA Teams included both middle school and high school STEM Club implementation). These five years of implementation have been filled with revision and reimagining, partially in an effort to meet the unique challenges of teaching and learning remotely, but also in response to lessons learned from each year's cohort of IDEA Teams. Cohort 1 received two-weeks of an in-person summer institute followed by monthly online meetings to touch base about implementation in the schools. This cohort's academic year ended with the rapid pivot to remote teaching and learning and all the stressors that brought with it. Cohort 2 was all online with fewer but more concentrated synchronous workshops spread across a two week period in the summer, followed by half day synchronous sessions during the school year. Cohort 3 participated in fewer days of online professional development in the summer, followed by monthly network meetings and a two-day hybrid workshop with some participating online while others met in-person. In year four, we determined it would be best to invite any teams from cohorts 1-3 to return for a deeper dive into the content and practices of this CISTEME365 initiative. During that year, we coordinated a winter conference for participants from all cohorts to share their lessons learned with other educators interested in issues of STEM equity and access. Cohort 5 came full circle back to the intensive summer institute followed by online check-in sessions; however, we ran this summer institute in conjunction with both a middle-school level and a high-school level summer camp which provided opportunities for the IDEA Team participants to learn alongside the students and reflect on equitable instructional practices happening in the camp classrooms.

In addition to the changes in professional development facilitation, the integration of content also evolved over time. In year one, the equity content was covered in isolation from the engineering projects with one week of equitable and inclusive STEM environment content followed by a week of technical experiences with the project-based engineering curriculum. In each subsequent year, the leadership team adjusted the content planning to better reflect the need for equity work to be embedded in STEM pedagogy, and not as something separate. The most consistent component of the CISTEME365 professional development model was the Action Research for Equity Project (AREP). Participants designed, implemented, and then presented their findings from an action research project where they investigated the impact of implementing one or more targeted equity and inclusion strategies in their STEM Clubs or classrooms. These projects required that the educators put their professional learning into action to solve an equity in STEM problem that they identified in their local contexts.

At the end of year three, the project's evaluators dove deep into the data available so far to spotlight successes and point to opportunities for further development. This paper summarizes a

set of key findings from across these reports and reflects on how these findings inform this ongoing work. These findings fall into three primary experiences of the CISTEME365 initiative: (1) Professional development focused on equity, access, and inclusion in STEM, (2) Collaboration within and between schools, and (3) Implementation during a global pandemic. The findings offer up many opportunities to celebrate, as well as lessons learned that will benefit others doing work in pre-college engineering education and equity in STEM.

Methodology

The findings shared in this report were identified by the initiative's internal and external evaluators. The internal evaluation process conducted by the partner organization National Alliance for Partnerships in Equity (NAPE) assesses the impact of the program's professional development models and content [4]. This evaluation used pre-, post-, and follow-up survey results from IDEA Team participants. The pre-survey was conducted at the start of the program, the post-survey was implemented at the end of the summer institute, and the follow-up survey was implemented after the action research projects had been completed. These surveys aimed to address a range of inquiries, including participant learning experiences, program alignment with professional goals, and perceived impact on student learning. The surveys also explored participant experiences with Network Improvement Communities, Capstone Projects, satisfaction ratings, and suggestions for improvement. Findings from surveys administered across three cohorts were presented, with some noted discrepancies in respondent numbers due to survey instrument inconsistencies. Analysis consisted of summary statistics and T-tests were used to assess the significance of difference between pre-, post-, and follow-up responses.

The external evaluation consisted of a mixed-methods approach for data collection and analysis [5, 6]. Data sources included interviews, observations, document reviews, and a literature review. Six interviews with project stakeholders were conducted via Zoom and transcribed. Observations were made during five project events, recorded on participant dynamics and activities. Document reviews examined various project materials, and a literature review contextualized emerging themes. Thematic coding of interview transcripts, observation protocols, and documents was performed collaboratively. The external evaluators used a data matrix for analysis. Findings from the literature review were then integrated throughout the report of the evaluation team's findings.

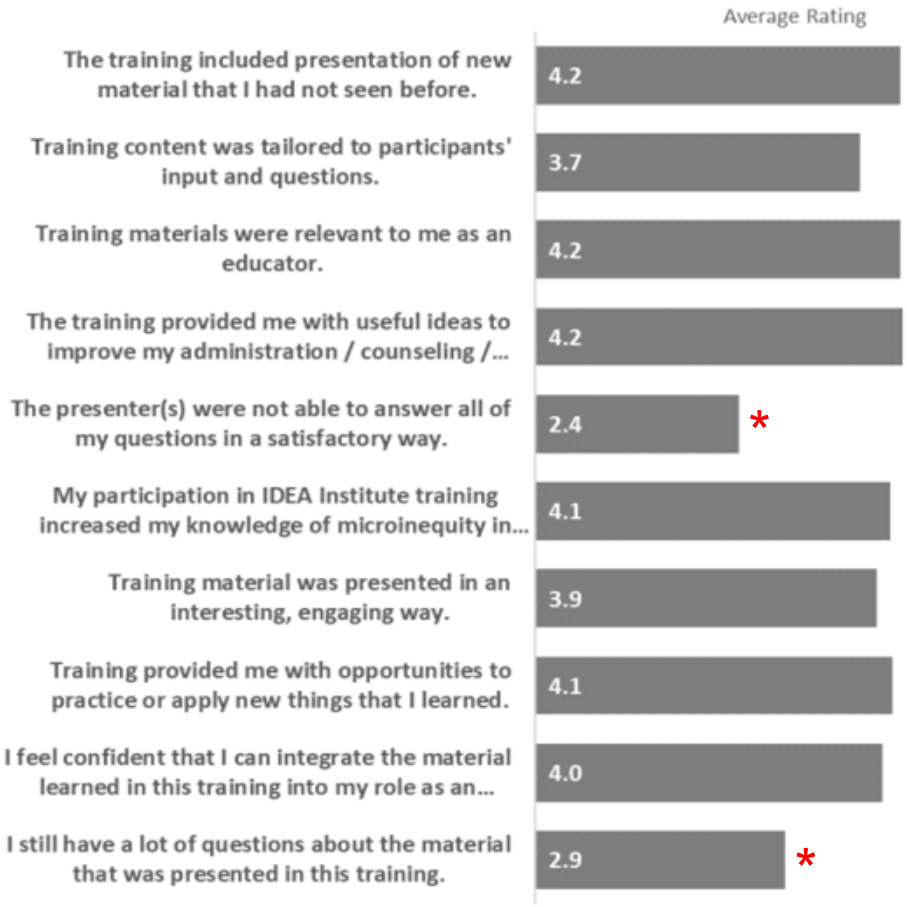
Findings

Three key categories of the CISTEME365 program's impact are highlighted from the evaluation of the experiences of Cohorts 1-3. The impacts and lessons learned fit into three distinct categories: (1) Professional development experiences, (2) Collaboration within and between schools, and (3) Navigation of barriers and challenges such as COVID 19.

Professional development experiences. As described above, the professional development for school staff in the CISTEME365 program used a year-round model with intensive electrical

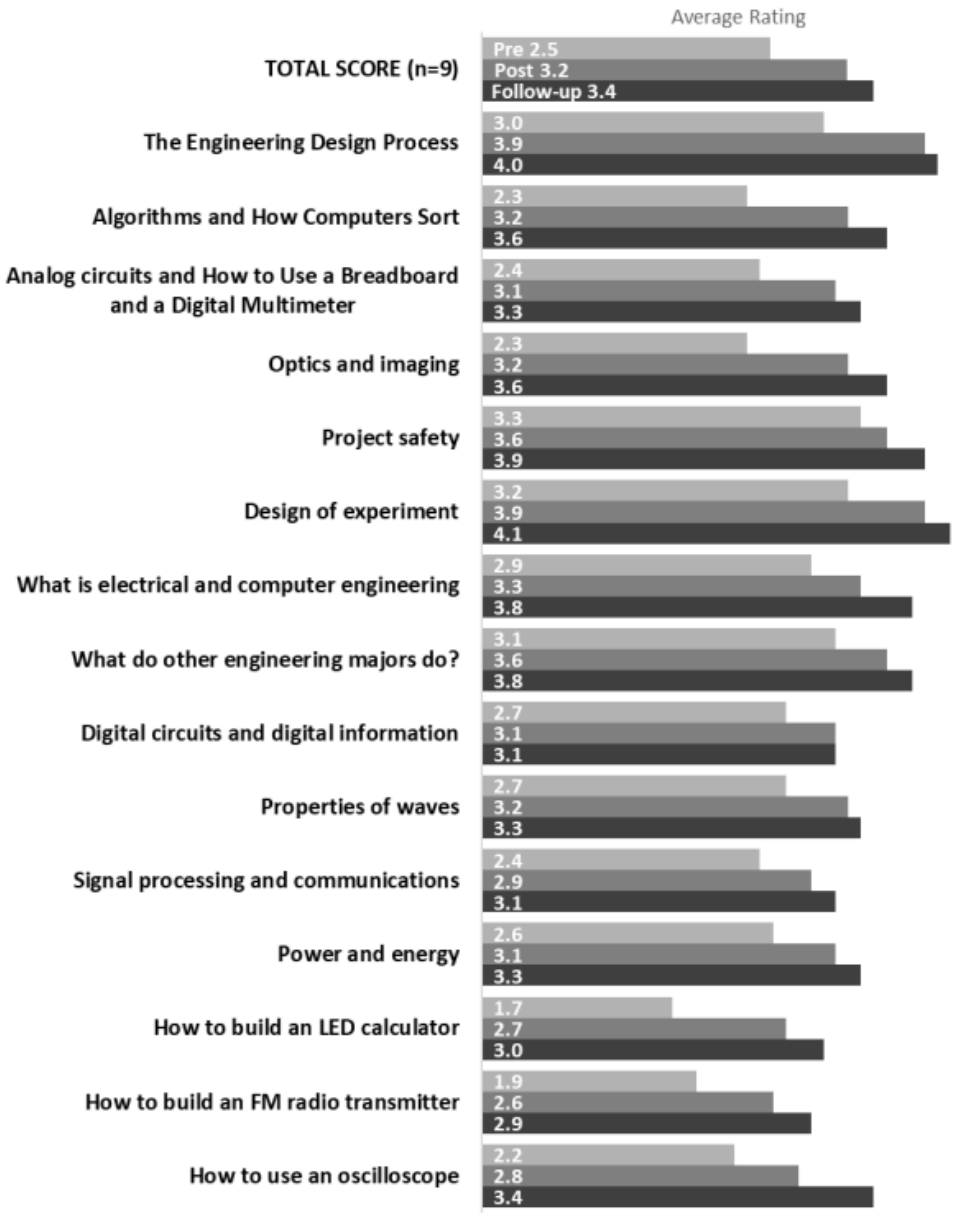
engineering technical content and diversity, equity, and inclusion content at the start, followed by monthly follow-up sessions and a capstone action research project that required intentional efforts to implement new strategies to address an identified equity and diversity concern within their home school. The CISTEME365 program's electrical engineering curriculum included a variety of topics including analog and digital circuits, properties of waves and signals, optics and imaging, algorithms, power and energy, and engineering design. Overall, 76% of participants reported altering their practice of teaching as a result of their CISTEME365 experience. A few of the notable ways participants altered their teaching included reinforcing a growth mindset in students (86%) and planning with administration to sustain self-efficacy strategies in the classroom (55%). 82% of participants rated the CISTEME365 program as being within the top 30% of effective professional development programs they experienced. And 55% of participants rated the CISTEME365 program as being within the top 10% of effective professional development programs they experienced. One participant shared that "*I am walking away with activities that can be implemented with fellow educators, parents and students. I am also walking away with a rigorous curriculum with a project based learning focus that will help spark students' interest in STEM pathways. For this I will certainly use what I have gained.*" Figure 1 shows the average ratings from one (not at all) to five (very much) of 10 different outcomes of the CISTEME365 program compiled across all three cohorts.

Figure 1: Post-institute survey ratings of CISTEME365 cohort years 1-3 outcomes. *Average ratings are the average score across all survey responses.* * *denotes an adverse index.*



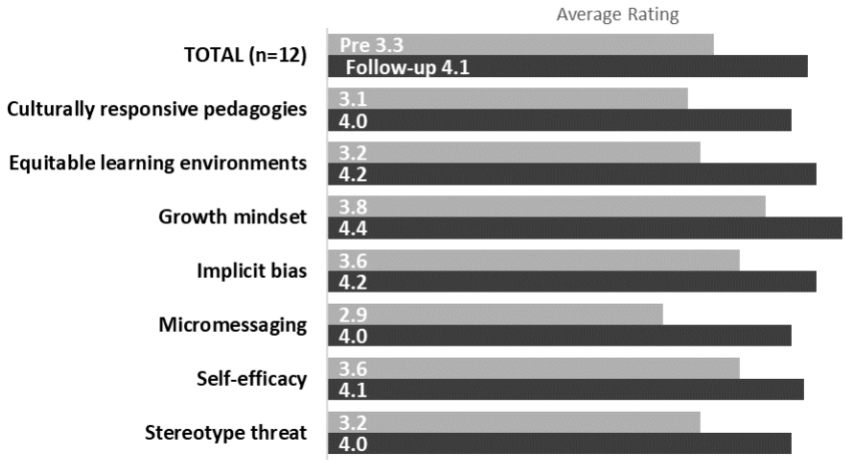
Across all three cohorts, participants reported an increased proficiency on 17 different topics by an average of 14%, which resulted in the overall proficiency going from "*beginner with basic knowledge*" to "*proficient usage at a satisfactory level*" (see figure 2). Survey participants responded to a scale from one (no knowledge) to five (expert). One participant said, "*The knowledge learned from* CISTEME365 *makes my robotics club more robust and engaging. For some, playing with the parts is enough, but I have ignored a lot of the formalities that make the club more valuable to students in the long run."*

Figure 2: Engineering Technical Content Self-Reported Ratings of Proficiency. *Average ratings are the average score across all survey responses.*



Participants were also asked to self-report their proficiency on seven equity-focused skills. The figure below shows the average ratings from one (no knowledge) to five (expert) of participants' self-reported proficiency level on seven equity-focused skills at the CISTEME365 across all three cohorts (see figure 3).

Figure 3: Equity and Inclusion Content Self-Reported Ratings of Proficiency. *Average ratings are the average score across all survey responses.*



Self-efficacy is an individual's belief in their ability to organize and execute courses of action required to accomplish a task [3]. This belief has been shown to be an important factor in resilience and success toward achieving outcomes. This is important for both educators and for young learners. Self-efficacy in teachers and counselors depends on a number of factors including their content knowledge as well as their skills in establishing an environment for learning [7]. In our case, we are assessing their beliefs in their ability to impact their students' sense of equity and inclusion in a STEM environment. On average, participants reported a 63% increase in self efficacy. After completing the CISTEME365 program, one counselor shared, "*I will continue to use the information and resources shared in my daily role as a counselor as well as present to teachers, staff and administrators the importance of building student's self-efficacy and how it relates to pathways to STEM careers.*"

Participants also shared how they expected to impact students' self efficacy after completing the CISTEME365 program. One response highlighted the importance of educators personally embracing self-efficacy and how that, in-turn, benefits the students: "*I believe this teaching can significantly impact student's feelings of self-efficacy and increase their exposure to STEM pathways, but I also believe there needs to be teaching on shifting the mindset of administrators and other team members. It often times feels as though we are on an island if no one else is on board.*" In a follow-up survey, which took place at the end of the school year, one participant shared how the leadership in their schools impacted the students' sense of self-efficacy: "*Having support from administration was key. The team received support, time, and resources to implement the projects. Because the barriers were removed, self-efficacy increased*." Both of these quotes related to the role of administrators highlights an issue that we aim to investigate further as this project comes to a close. Only a few of our IDEA Teams included administrators, and anecdotally anecdotally including administrators seemed to enhance the success and sustainability of those teams.

Collaboration within and between schools. The CISTEME365 initiative established a primary goal of creating a professional network, and we were purposeful in requiring participants to be part of cross-role IDEA Teams. The professional makeup of IDEA Team participants ranged from teachers (51%), administrators (8%), counselors (14%), and others (e.g. post secondary coach, student engagement advocate, special education, etc. 27%). In the subsequent section, the quotes from participants highlight how multiple roles within the school work together to implement something new or different. While individual reflection and development matters, research shows that collaboration and interaction holds greater power for creating change [8]. The theme of within and across school collaboration was evident across evaluation reports. 60% of participants in Cohorts 2 and 3 reported being referred to the CISTEME365 program by another colleague. One participant from the first cohort shared that "*I think the colleagues that were most impacted were the counselors and social workers that are constantly looking for ways to help students emotionally as well as academically. I think they attempted to reach out more to students*." Another participant from the third cohort shared, "*The social workers and teachers were impacted in helping students access the STEM club. When students experienced success in the STEM club, other staff noticed and that had a ripple effect.*" Another area we want to explore further in the final year of this grant is that of the collaboration within the IDEA Teams, as well as any evidence of influence or spread of ideas as a result of the cross-school networking.

Navigation of barriers and challenges. The last aspect of the CISTEME365 program that we wish to highlight is how participants navigated through barriers and challenges, especially that of COVID-19 which heavily impacted the implementation and experiences of Cohorts 1-3. Logistic issues of program implementation, difficulty collecting and organizing data, getting support throughout various levels of their departments, and insufficient time to implement things are just a few of the challenges that participants experienced. In the first cohort of the CISTEME365 program, schools encountered challenges in maintaining the continuity of STEM clubs, primarily stemming from staff turnover and disruptions in student engagement induced by the pandemic. Informal discussions conducted during a professional development session unveiled participants' observations regarding the hurdles encountered in recruiting students for summer STEM activities.

The CISTEME365 I-TEST grant proposal set a target of 100 students annually for participation in summer programming; however, project teams encountered a number of obstacles in securing registrations for STEM summer programs (see table 1 containing Cohort 1 summer program attendance). One leader of the project explained: "*[When the pandemic hit,] It was really hard to promote the fact that we were still going to do summer camps. So, we did a shift and we provided virtual summer camp opportunities. But we had a hard time getting the word out about that. And so we weren't able to get student participation in those virtual camps like we'd hoped*." However, these challenges to recruit participation continued across the years, showing slight increases in participant count each year but never approaching the hoped for participation rate of 100 students a year. IDEA Team participants added insight from the students' perspective, sharing that the

competing allure of alternative opportunities, such as employment, which offer greater financial incentives competed and won over an interest in joining the summer STEM programs. Additionally, reflections highlighted the prevalence of divergent interests among male students, with a notable inclination towards sports activities, presenting scheduling conflicts with STEM club participation.

Table 1: Cohort 1's 2020-2021 summer camp attendance.

Program	# of Students	# of Teachers
University of Illinois Summer Programs	6	2
Grainger Engineering Young Scholars summer 2021 research program	3	2
Collaboration with the research team from the Center for High-Efficiency Electrical Technologies for Aircraft (CHEETA)	2	1
Collaboration with Nuclear Physics research group	1	1
Week Long Virtual Camps	3	0
Mechanical Sciences and Engineering summer camp	1	0
Chemical Engineering summer camp	1	0
Civil and Environmental Engineering Summer Camp	1	0

Despite the challenge of not reaching as many students as intended, one co-PI of the CISTEME365 program shared how the organizing team pivoted to make the virtual summer program as impactful as possible: "*So, we committed to putting together STEM kits that could be mailed home for hands-on projects. And, secondly, we knew that this needed to be not like school, it needed to be like camp. We wanted kids to leave camp with new friends, a new social group that they've built some relationships with. So we hired counselors to do social activities and created small groups that they stuck with for the whole time.*"

Furthermore, throughout the school year, educators in the CISTEME365 program had to navigate not only the new methods of teaching due to the pandemic but also how to implement the things they learned from the CISTEME365 program in their STEM club settings. Table 2 encapsulates the difficulty several participants experienced during their school year implementation efforts.

Table 2: Challenges Reported by IDEA Team Participants in the Follow-Up Survey.

Area of Difficulty	Participant's Remarks
Time management	*"I know what I would like to use from the CISTEME365 program , I just didn't have time."*
Student-to-student interaction	"*Students with lower self-efficacy at the beginning of the initiative had a more difficult time keeping up and fitting in with students with higher self-efficacy. "*
Overall engagement with students	*"Online learning and student engagement have been difficult. Majority of students were not engaged in the class activities"*

The project leaders also experienced several issues with data collection which can be summarized in the following interview excerpt: "*Yeah, the other thing that's been difficult with COVID is getting consent for the surveys. So the educational research aspects, and the timing and getting permissions from Chicago public schools to work with the students. That was an amazing undertaking that did just to even get us permission to be able to implement the survey. But I think the timing of when the surveys are going out on some of those parts, students haven't done the pre-survey yet. So, there are going to be challenges with getting useful data out of it. Because it's, yeah, we weren't even we didn't have permission to talk to the students. And we still don't. It's the staff at the schools that have to work with the students and collect the data for us and send it to us.* "

Closing

The presented findings from the CISTEME365 initiative highlight how effective equitable access to project-based engineering experiences was given to students who otherwise would have limited to no exposure to STEM. This initiative empowered students, educators, and administrators through the CISTEME365 summer institute, STEM Clubs, and other deliberate efforts that facilitated equitable learning environments of STEM concepts. An increased self-efficacy among instructors and students, an increased proficiency in STEM-related topics for both educators and students, and intentional changes to teaching practices promoted students' disposition and engagement with STEM-related topics. The CISTEME365 initiative equipped educators with the tools necessary to adapt and make these accomplishments despite disruptions like logistical hurdles and inconsistent department support in the midst of the COVID19 pandemic. This mid-program evaluation also revealed a number of issues to be explored further. The role of administrators is important to school change initiatives like these. What can we learn

from those IDEA Teams that included school or district leadership from the outset as members of the collaborative team? Now that we are back to an in-person implementation and have expanded to school districts in Texas and Arizona, what types of lasting effects did COVID-19 shifts have on our subsequent professional development models? We believe that because several different models ranging from in-person to virtual to hybrid with varying levels of integration of STEM and DEI concepts were explored, lessons learned from this initiative will inform future endeavors aimed at broadening equity in STEM education and careers.

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