

High School Teachers' Preparedness to Implement Blended e4usa+FIRST models in Underserved Communities (Work in Progress)

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Abstract

Efforts to provide pre-college students with engineering or engineering-related experiences are on the rise in the United States. These efforts are typically undertaken independently of one another and are often in competition to garner greater participation. e4usa+FIRST is a first-of-its-kind collaboration between two pre-college engineering/STEM education efforts that aims to break down existing silos between programs. The project was piloted in nine US high schools within underserved areas. The following study examines high school teacher's preparedness to teach a blended offering between engineering and robotics curricula following a summer professional development (PD) program. Pilot teachers (n = 10) participated in focus groups to share their perceptions of readiness to implement the blended e4usa+FIRST curriculum. Data was analyzed using open coding and constant comparison methods. Most teachers reported confidence in teaching the blended offering, shared their plans and expectations, and brought up concerns regarding time and sustaining student interest especially during a time of pandemic. This project has implications for pre-college engineering education efforts as it could provide a foundational understanding of how two successful programs can be blended, playing a critical role in educating high school students in underserved communities to experience engineering.

Introduction

Pre-college engineering education programs have been a source of inspiration for more recruitment into STEM due to their integrated and interdisciplinary approach to learning and skill development [1–3]. The availability of such programs is one step toward meeting industry demands for highly trained science, technology, engineering, and math (STEM) professionals, which are growing at a rate not supported by current post-secondary student enrollments [2, 4]. Pre-college efforts to excite students about possible careers in STEM have been made primarily in isolation from one another, including professional development designed to prepare and train teachers to successfully implement a program and encourage student participation.

The e4usa+FIRST program is an unprecedented effort that establishes a partnership between two existing STEM programs – e4usa and FIRST – to leverage collective strengths toward furthering the democratization of engineering education for all. It is aimed at preparing teachers to educate, inform, and excite youth about careers in engineering, for greater overall impact on the future engineering workforce. e4usa+FIRST brings a unique, high-quality blend of STEM opportunities to underserved communities through a coalition of nonprofits, schools, researchers, community, and industry partners. The result will be a better educated citizenship with a growing interest in engineering and engineering careers.

This study evaluates the preparedness of high school teachers in underserved communities following a summer professional development workshop introducing a myriad of technically blended e4usa+FIRST models. Models were developed through a kick-off workshop and multiple development sprints. The research questions that guided this study were: 1) How do teachers evaluate the effectiveness (format, activities, and instructional strategies) of the e4usa+FIRST PD?, and 2) What are teachers' perceived expectations, plans, and challenges regarding implementation of e4usa+FIRST in their classroom?

Literature Review

Over the last few decades, STEM education has been focused on developing successful programs that expand the numbers of secondary students transitioning into science and technology fields as isolated efforts [5–7]. Integrating engineering into the pre-college classrooms, as both an avenue to technological literacy and to enhance the engineering pathways, is critical to broadening participation [8]. This integration

emphasizes the need for inquiry-based, culturally sensitive programs, aligned with both school curricula and STEM career needs, that engage students in hands-on projects, community engagement, and connections with industry [9, 10]. Implementation of such programs would require instructional strategies that are aligned with engineering needs and capture students' interest [11].

The effectiveness of teachers is crucial to this effort [12]. Ensuring that classroom instruction focuses both on the logical/mathematical intelligences as well as the leadership and social skills development can sometimes be challenging for teachers [8]. Teachers need professional development to train teachers for effective understanding and facilitation of: a) subject matter, b) learners and learning, and c) teaching methods in engineering and technology [8]. Four key components of engineering teacher professional development are developing technology skills, learning about how to teach technology, incorporating tools and motivation to continue their own learning, and continuing long-term professional development [13]. Providing training through professional development to teachers at underserved schools is a necessary step toward preparing a more diverse future workforce living in a 21st century society [14].

Enhancement of teacher competence is the underlying goal of most professional development efforts. Internal (e.g., beliefs, self-efficacy, knowledge for technology integration) and external (e.g., technology resources and support) factors influence technology adoption and integration in instructional practices [15]. Prior literature has considered multiple constructs (e.g., knowledge, attitudes, and perceptions) of teachers in the integration of technology in the classroom [15, 16]. Teachers' cognitive and/or affective processing can in turn induce behavior changes in teaching these critical technology skills to students [16]. This paper seeks to evaluate the direct relationship between teachers' preparedness and attitudes toward implementing a blended engineering and robotics program for the first time.

Professional Development Context

The first year of the e4usa+FIRST project engaged ten high school teachers in an effort to bring a blended engineering and robotics course to schools in underserved communities. The teachers attended a summer PD which took place virtually over two and a half weeks in July 2021. The PD focused on: 1) FIRST Tech Challenge robotics training, 2) e4usa professional development, and 3) e4usa+FIRST blended implementation sessions. These three sets of activities built on each other to enable and empower teachers to implement the blended curricula in their classrooms. FIRST training sessions aimed to provide understanding of the reusable FIRST robotics kit, common game rules, and the specific FIRST season challenge. Next, the teachers participated in e4usa professional development sessions designed to impart curricular knowledge with collaborative hands-on design activities and assignments. Finally, teachers were introduced to different ways of blending the activities from the two programs. Teachers reviewed and discussed various approaches while working with the project team members.

Methods

Participants

Participants included ten teachers currently teaching the blended e4usa+FIRST curriculum in a variety – public, charter, and alternative – high schools located in six US states or territories. The group included five White males, three White females, one Hispanic male, and one African American male. Their teaching experience ranged from one to 25 years, with an average of 12 years. The average engineering teaching experience among the participants was 3 years, ranging from 0 to 9 years. Participants also reported a wide range of exposure to robotics that included none, brief introduction during college education, a couple of years of experience running a robotics club or coaching as a parent, and a certification in VEX robotics.

Data collection and analysis

Data sources included focus groups conducted at the end of the summer PD. Participants were divided in two groups and two members of the research team concurrently conducted a 60-minute focus group with the teachers. The same semi-structured protocol was used for both focus groups. Focus group questions were designed to better understand teacher perceptions of the summer PD as well as their readiness to teach the blended curriculum. Questions asked teachers to share contributions to: 1) contribution to confidence in teaching e4usa+FIRST, 2) expectations for e4usa+FIRST implementation, 3) plans for e4usa+FIRST implementation, and 4) concerns or suggestions. Both focus groups were audio-recorded and transcribed. Transcripts were analyzed by two research team members using an inductive coding approach with the constant comparative method [15, 16]. The codes were reviewed by other members of the research team. Differences were resolved using research team discussions to come to an agreement about the final codes and resulting themes.

Results

Contributions to confidence in teaching e4usa+FIRST

Teachers noted that several factors contributed to their overall confidence in implementing a blended model in their classroom. The first factor focused on the collaboration, brainstorming, training, and extensive support provided by the training and support team during the PD. Systems of support noted were the community of practice, access to expert support, materials, and on-site lesson plan creation. One teacher noted:

“I am closer to a positive feeling about the beginning of the school year. It seems that we have a great community. I am really feeling confident about implementing the program. This community has shared knowledge about other available opportunities. And with some of the e4USA activities such as wanting to get a laser cutter and so on, it was helpful to make new connections with people that can provide guidance.”

The second factor noted was additional support from commitments made by their school administration, organizations, and industry partners. It is important to note that the implementation of the program is highly dependent on affective factors such as the school administration’s support for the curricular and /or extracurricular activities of the program and opportunities for students to extend their learning beyond the program. The following is a representative quote from one teacher in this space:

“I feel that I am supported by my school; my school certainly encourages both e4usa and FIRST programs. The community and support systems created by the e4usa+FIRST PD helped cultivate collaboration and support among teachers. I just think that the community is wonderful. I felt a strong set of people to go through this... And I think it's just a good thing you all set this up.”

The most highly cited aspects contributing to participating teacher’s confidence were open access resources and interactive knowledge diffusion approaches. For example, one teacher noted:

I didn’t know much of the robotics stuff before this. I’ve never coded anything in my life, so that was super-duper helpful, and I really appreciated that. Discussing pathways for blending the two curriculums contributed to a better understanding of the subjects, especially for us who are first-year teachers. As far as integrating FIRST with e4usa, I feel that it’s been very beneficial to discuss potential programming and potential curriculum pathways in order to blend those two together.”

The technology resources and hands-on practice during the PD were cited as helpful in developing skills through exploration and inquiry.

Expectations for e4usa+FIRST Implementation

Teachers suggested that the blended e4usa+FIRST program will likely develop students' professional skills, increase access to resources, and foster interest in engineering. The participating teachers also expected students to develop professional skills such as teamwork and problem solving. One teacher noted that they expect this course to be a better introduction to engineering and robotics for students with limited experience in STEM:

"I like that e4usa will probably be a much easier starting point for students who want to go and be a part of the robotics part of the tech stuff." Teachers expect the course to increase resources to students that they may not have had access to previously, including materials and hands-on experiences. Engineering classes [were] not funded at my school, I just did it without funding, because the students, the students really needed it. Now, we have an actual engineering / robotics program"

Teachers overall had high expectations that the e4usa+FIRST program would provide a positive experience for students within their underserved schools.

Plans for e4usa+FIRST implementation

Teachers shared their plans to improve their ideas in blending e4usa and FIRST for their local context. A priority was made to connect the curriculum to the real world to demonstrate applicability of the content outside of the classroom. Many suggested leveraging the community of practice and noted the importance of engaging in the FIRST competitions. Finally, the PD helped teachers to decide how to blend engineering and robotics:

"I'm trying not to separate the two because we are trying to blend it. So, although this is the main concept here is engineering, robotics complements it. Maybe engineering will be the topic of discussion, but robotics is a part of engineering. You must understand engineering to do robotics."
"I know, this is a pilot stage, and we are all kind of working together on this. I think that's what's going to help us grow is seeing what's working, see what's not, see what we can change."

Concerns or suggestions

Some concerns were expressed about the PD and suggestions were offered to improve the experience going forward. Many felt the robotics PD workload for those with little engineering and technology knowledge was a bit too much. One teacher noted:

"I just did not anticipate so much of the asynchronous work during the PD. I did not anticipate nor expect this level of robotics activities such as programming."

Suggestions to improve this aspect of the experience included engaging participants in pre-PD exercises before the PD. Such activities would allow teachers to gain better familiarity with the programs, activities, and technology, which would help them feel less overwhelmed during the PD.

Some teachers expressed concerns with access to resources, time constraints, online teaching during a pandemic, garnering student's interest, nervousness and serving as a mentor to other teachers.

"I was just nervous that two programs all in one year was a little much since I'm so new at this in my second year in STEM, so I'm going to work towards that for next year. My biggest challenges will be, getting them interested in things, you know, the hands-on activities, trying to overcome some of their, 'oh, I can't do that. I don't know that' or, trying to overcome some of their fears and their challenges and just cultivate interest in the class."

Additional concerns were made about physical resources, such as classroom space and the ability to take students to FIRST competitions were also made.

Discussion and Future Work

Teachers need professional development to train teachers for effective understanding and facilitation of: a) subject matter, b) learners and learning, and c) teaching methods in engineering and technology [14]. The goal of the e4usa+FIRST project is to leverage the collective strength of two programs. The week-long PD, participant interactions, content, and delivery method of the training were generally received positively by e4usa+FIRST teachers, including those with little experience and content knowledge. The results show that e4usa+FIRST teachers with past e4usa involvement and/or knowledge of robotics technology demonstrated greater comfort with the PD and its discipline-specific content. Teachers with little to no experience started feeling overwhelmed by the learning experiences, which led to some apprehension in the beginning. They later grew with the training content emphasizing the support available to them was crucial.

The project team will work to revise the PD experience, including greater access to resources and experts. A community of practice, which was initiated during the pilot year PD, will be further cultivated through reflection posts, webinars, and additional PD. Additional data from the pilot cohort of teachers is still being examined to further examine the success of the initial PD and to inform future versions of the PD.

This collaboration made it clear that there are opportunities to combine classroom and project-based learning more effectively. Robotics competitions have been a leading form of project-based learning (PBL) in STEM for decades, but adoption in underserved communities has been limited. Our research identified opportunities to develop project-based learning resources that will address specific barriers to participation including the use of complex jargon, assumption of basic skills, and reliance on expensive hardware and proprietary systems. These barriers seem obvious in retrospect, but there are unconscious assumptions in program design that can be hard to overcome. One focus of our future work will be to leverage industry advances to develop more accessible resources for project-based learning in engineering. For example, sophisticated control systems used in competition robotics can cost hundreds of dollars, presenting a barrier to access for individual students. Open-source microcontrollers, like the Raspberry Pi Pico, are powerful enough to provide a comparable capability at a fraction of the cost. To the extent that it is possible to adopt more standardized open-source hardware and software platforms, the barriers to participation will be reduced by providing more consistent support through tutorials, help desks, and other resources. This rethinking of PBL resources not only provides an opportunity to eliminate barriers but could enhance learning outcomes by embracing design constraints which closely mirror the real-world constraints of the professional disciplines themselves. It is through our work in e4usa+FIRST that we hope to make these strides in increasing opportunities for all students, while improving the overall quality of pre-college engineering education everywhere.

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