Board 127: Collaborative Multidisciplinary Engineering Design Experiences for Teachers (CoMET) Train the Trainer Model of Supports

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Collaborative Multidisciplinary Engineering Design Experiences for Teachers (CoMET) Train the Trainer Model of Supports Type 5 Work in Progress

The K-12 learning environment is evolving at an unprecedented pace [1]. These changing environments have the potential to support effective inclusive models that, when aligned with evidence-based instructional strategies and practices, can support a range of student educational needs, behavior, and outcomes in the modern world [2]. The field requires leading teacher educators who are prepared to develop and deliver effective interventions in technology-enriched environments in accordance with evidence-based practices to benefit students in STEM education [3].

A primary reason for the discrepancy between the goals associated with appropriate technology consideration and current practice is a lack of teacher preparation [4]. A secondary cause is teacher resistance to embracing the pedagogical practices necessary to integrate technology into instructional practice effectively [5]. New systems for understanding the benefits and barriers of technology integration and for developing communities of practice, experiencing integration, fostering effective implementation, and managing technology environments are critical to providing all students with the knowledge and skills necessary for active participation in a democratic society.

Technological innovation and lack of prepared personnel.

The fast-paced growth of the education technology market shows no signs of deceleration. In 2016, venture-capital funding in educational technology totaled well over $1 billion. The CB Insights platform, which tracks investments in private companies, puts the number at $1.7 billion. EdSurge, an education-technology reporting website estimates the investment total at $1.6 billion. Education technology companies are investing enormous capital to modernize education for all students. Entirely new education models (e.g., K-12 blended and fully online programs) are currently in development or have been deployed with direct implications for students and their teachers. Collectively, these trends suggest technology is a primary component of education for all students [6] and command professionals with skillsets significantly different from those available in current teacher education models [4].

Unfortunately, educational technology selection and implementation in STEM has been inconsistent for decades [5]. The field should not expect commercial technology to have desired effects without close collaboration with pedagogical experts [4] who can lead best practice. The objective of this RET site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers (CoMET) program is to provide K-12 teachers with a hands-on engineering design experience covering all aspects of the Internet-of-Things, from the manufacturing of a sensor, to the hardware and software that allows it to connect to the Internet. In order to support the STEM educational services for teachers and students in K-12, our site program aims at creating competent teacher trainers who will ensure quality pre-service and in-service teacher education, by providing multidisciplinary experiences that are relevant to the current technical development. Teachers receive an immersive experience working alongside faculty and graduate students as well as undergraduate students participating as part of the NSF REU Site: Internet of Things [14].

Project goals and objectives

The Research Experience for Teachers (RET) site program was developed to involve 10 teachers over 8 weeks in summer with 1 week in the following year. This model, used in Year One, was adjusted in Year Two to involve 12 teachers for 6 weeks with the follow-on training untouched. Teachers are selected to develop RET inspired lesson plans, which they implement in their classroom the following school year. Recruitment includes mailings (electronic and direct) to principals and STEM teachers in the six-county region of Central Florida and tabling at teacher events. Applications are reviewed to determine teachers meet the qualifications and phone interviews are conducted for selecting the finalists. Selected applicants are contacted with a short window for confirming their participation. Demographics for the selected RET teachers are found in Table 1. Participants receive a stipend for the summer-time component, plus additional funding for participation in the Winter Conference and Spring Meeting activities.

Table 1. RET CoMET teacher demographics

Cohort	Male	Female	High School	Middle School	African American	Hispanic
2017	5	5	5	5	3	3
2018	6	5	10	1	4	0
2019*	4	9	8	5	1	2

*estimated as selection is in progress

RET researchers assembled a team of faculty from Computer Science and Electrical, Environmental, and Mechanical Engineering with demonstrated success in research and education who work together to engage the teachers in streamlined research activities (i.e., device design, fabrication, testing, programming and validation). Over the RET Summer Experience, faculty provide lectures to introduce their research. The teachers then work with the mentor to participate in learning modules in sequence, where they will gain the knowledge and skills needed for constructing connected sensor devices by the end of the summer.

The summer schedule runs from 9am – 5pm Monday through Friday starting with an orientation for all participants and faculty then concluding with a library session, laboratory safety and laboratory tours in the afternoon of Day One. Upon conclusion of these introductory activities, the participants begin working with faculty mentors to collaborate on research and development. Each week a group seminar is held where faculty introduce their research. The teachers are hosted by the faculty member's research laboratory and work together with the mentor in order to learn and participate in each research component. In Year One teachers participated in five modules over eight weeks. In Year Two the program was adjusted to four modules over six weeks, with two sets of closely related modules combined for efficiency. Over this time, participants pick up the knowledge and skillsets for constructing connected sensor devices. In the final week of the program, teachers present their learning outcomes and lesson plans to be implemented the following school year. Upon completion of the program, the teachers are given one course credit certification. The detailed description of the project modules the teachers are engaged in is available in a prior manuscript [6].

Train-the-trainer model

One unique aspect of our program lies in the engagement of teachers in various facets of scientific and engineering methods based on Train-the-Trainer model with job rotation in collaborative team environment. We used the Train-the-Trainer Model in setting up our RET Site program to provide mentors/trainers with competencies that will enable them to effectively mentor, facilitate knowledge acquisition, application, and skills in use of the engineering design experiences in K-12 settings for other teachers.

The teachers share their created lesson plans/materials at local schools, conferences and online. RET participants also present at a statewide teacher conference hosted by UCF and are encouraged to find other regional or national conferences for sharing their work. Through our RET Site program, also host 30 plus teacher participants to provide professional development sessions in their schools and also invite colleagues to our planned workshops. Finally, we further enhance the teachers' broader impacts by sharing the lessons created through a website called Teach Engineering.org.

The project team utilized a triad of interwoven theoretical frameworks to guide the development of the train the trainer manual. First is the iterative design process. Iterative design involves the repeated development, testing, and redesign of engineering principles and user interface components [9]. This theory uses rapid prototyping cycles followed by end-user evaluation at periodic intervals throughout the process. User Interface testing during the iterative design process allows data and feedback to provide information through multiple pathways using cyclic methodologies that meet each user's unique needs [10].

Over the past decade, there has been a shift in the way teachers work with students with academic science instruction to a more teamwork or "hands-on" approach that emphasizes the use of technology. In 2004, *connectivism* was presented as a theory that addressed learning in complex, social, networked environments [11]. Connectivism provides a framework for understanding how learning occurs by emphasizing the role of information technology in creating and manipulating knowledge [11]. From a connectivist perspective, learning occurs when connections between the project team and ideas, concepts, opinions, and perspectives are made. Technology has a key role in facilitating the connections necessary for learning to occur. Connectivism "stresses the development of 'metaskills' for evaluating and managing information and network connections and notes the importance of information pattern recognition as a learning strategy" [12].

Finally, the project team utilizes Universal Design for Learning as a framework to guide the accessibility and engagement of teachers and students. Universal Design for Learning (UDL) is a framework for the design and implementation of instructional materials that meet the needs of students by proactively circumventing curriculum barriers [13]. This is accomplished through careful consideration of the broad range of needs, motivations, and strengths across ALL learners, including traditionally marginalized populations such as English language learners, those with disabilities, and students with diverse cultural backgrounds. Using UDL, instruction is framed around three guiding principles: (a) multiple means of engagement (i.e., considering how to engage students through a variety of pathways), (b) multiple means of representation (i.e., providing content through multiple methods), and (c) multiple means of action and expression: (i.e., providing opportunities for students to demonstrate their understanding in multiple ways). Each principle is further delineated by guidelines, and subsequent checkpoints.

The implementation of UDL focuses on integrating the three principles across four critical instructional elements: Clear Goals, Intentional Planning for Learner Variability, Flexible Methods and Materials, and Timely Progress Monitoring [5]. These critical elements are implemented using an instructional design model that includes five steps: (1) Establish Clear Outcomes, (2) Anticipate Learner Variability, (3) Establish Clear Assessment and Measurement Plans, (4) Design the Instructional Experience, and (5) Reflect and Develop New Understandings. UDL makes use of a variety of technology-enhanced, evidence-based, strategies and instructional resources to enhance instruction for all students.

Preliminary Outcomes of RET and Train the Trainer Model of Supports

Early results from (two of a three year project) the pre-experience survey showed that, going into the program, the teachers' expectations aligned with the program design. They wanted to improve their teaching and take away tools to better engage their students. At the end of the program, the teachers expressed satisfaction with the program and its mentors. They also reported that they experienced several types of professional learning. Growth in teachers' Research Self-Efficacy ($t7 = 5.1$, $p = 0.001$) and Confidence in Teaching ($t7 = 3.8$, $p = 0.007$) were evidenced through a pre-post-questionnaire. Finally, 89% would definitely recommend this professional development experience to others. Reflections from the teachers later, after they got back in their classrooms and implemented their RET lessons, indicated that they were successful. They reported that students enjoyed working hands-on with the subject under study, even when the lessons were challenging. Two teachers specifically reported that students showed increased interest in STEM fields. Another, described a novel application by the students—using their knowledge of electrical resistance to compose music with piezo buzzers. We have investigated content development, scheduling, the first stage of recruitment, and how well participants are identified and recruited. This evaluation approach incorporates process and outcome evaluation each year, which produce measures to help assess the implementation of the RET project, and play an important role in validating and directing the project.

Conclusion

The experiences and dissemination efforts thus far are encouraging as we address the changing landscape of education. Our innovative use of Teach Engineering.org has allowed us to validate and disseminate critical lessons in the area of Internet of Things for secondary settings. In addition, we have been encouraged by the participation in the Train the Trainer model where select returning cohort teachers return the following summer to provide a much-needed peer support and mentoring as new cohort teachers obtain new knowledge. Finally, we are collecting data on the number of students impacted in the secondary school setting and information is being shared across reginal, national, and international venues. We will continue to iterate the train the trainer model with more feedback forthcoming in the last year of this NSF funded project.

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