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Research Experiences for School Teachers and Community College Instructors in Smart-Vehicles: Initial Implementation and Assessment

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Abstract

We have successfully finished our summer program in our National Science Foundation (NSF) supported Research Experiences for Teachers (RET) Site entitled "Enriching the Professional Development of School Teachers & Community College Faculty in Rural Michigan - An RET Site on Smart Vehicles." The summer program was six weeks long and hosted five community college faculty, five in-service teachers (high school science) and five pre-service teachers (integrated science majors). Participants were split into five groups and teamed up with an engineering faculty and an engineering undergraduate student each. During their 40 hours/week work schedule, participants worked on faculty-supervised research projects for 25 hours/week and the remaining time was reserved for development of classroom unit plans.

This paper presents details about the RET Site's management and discusses lessons learned from our experiences. Preliminary assessment results will be presented and discussed. Finally, we will conclude with the overall lessons we learned from this experience and discuss next summer's plans as a result of our analysis and self-reflections.

1. Introduction

In recent years, Science Technology Engineering and Mathematics (STEM) educators, professionals, business leaders, and policymakers have recognized and highlighted the requirement to build a strong and technologically trained workforce. This requires a strong education system with qualified and trained educators. While the American college level educators are willing to train this workforce, the K-12 education system is currently challenged by a crisis of inadequate teacher preparation in STEM disciplines leading to low student preparation and performance[1]. Furthermore, the K-12 science teachers will be required to follow the Next Generation Science Standards (NGSS) with a strong overarching focus on engineering[2].

As most K-12 science teachers do not have any training in engineering concepts, there is a lack of high-quality curricular materials and professional development programs in this area[3]. New inclusive professional development programs for K-12 teachers are required to address the new education standards for improved classroom teaching and learning[4-7]. These professional development programs are a catalyst for K-12 educational reform and should include technological content and resources that expand their knowledge and ability to apply this knowledge in their classroom. Some of the key factors for these professional development programs include 1) active engagement with hands-on activity related to the new science standards; 2) collaboration, sharing, and exchange of ideas and practices; 3) interaction with college level educators; and 4) active participation in pedagogy workshops.

Based on these key factors and information available in the Council of Chief State School Officers report[8], the National Science Foundation (NSF) Research Experience for Teachers (RET) program at Central Michigan University (CMU) has been designed with the following objectives: (1) strengthen the partnership between CMU School of Engineering and Technology (SET), Science/Mathematics/Technology Center (SMTC), regional community colleges, middle and high school STEM ISTs and PSTs (CMU science education majors) in the northern lower peninsula of Michigan; (2) broaden and deepen science and technology teacher/faculty's content knowledge and pedagogical tools by engaging them in engineering research to solve open-ended problems; (3) improve middle school, high school, and community college student science and technology achievement, and (4) stimulate student interest in STEM careers through improved instruction and curriculum delivered by RET participants in rural Michigan.

These objectives were to be achieved through (a) engaging participants in cutting-edge research on smart vehicles through a vibrant team of CMU engineering faculty mentors, community college faculty (CCF), IST, PST, and undergraduate engineering students; (b) developing skills and abilities of participants related to their roles as education leaders, curriculum developers, and assessment designers; (c) establishing academic year follow-up mechanisms including Instructional Coaching, Quarterly Team Meetings to meet program requirements on a timely basis, and Cross Classroom Collaboration to ensure implementation of newly developed curriculum modules; (d) disseminating findings to other regional educators through the annual CMU High-Impact Teaching Symposium, as well as publications in conferences and journals; (e) the annual CMU STEM Day outreach event to engage secondary school students in STEM disciplines.

2. Program Orientation and Schedule

Participant recruitment and program efforts started right after receipt of the RET site award notification. Initially, the principal investigator (PI) worked with the faculty members to develop diverse projects with the underlying theme of Smart-Vehicles. During the same time, the PI and Co-PI drafted the application material for participant recruitment and informed schools in the Intermediate School Districts (ISD) of the opportunity. From the pool of applications received, 15 were chosen for the pilot program in summer 2016. Based on the number of participants recruited, five teams were formed with each team comprising of one community college faculty, one IST, one PST, one undergraduate ES, and one engineering faculty member.

The CMU RET program was a six-week program, began with an orientation session for all participants. This orientation started with welcome and participant introductions, followed by explaining the rationale behind chosen team model, and engineering faculty members presenting their respective projects. Additional aspects discussed include obtaining identification cards, parking permits, CMU campus tour, engineering and technology building tour, coaching sessions on team building, classroom flipping techniques, and engineering programs at CMU.

In the second week, participants spent 25 hours on research, 8 hours on coaching (teacher training), 4 hours on group reflections and team planning, and 3 hours visiting other research labs and attending talks of various individuals. Some of the research projects that participants were involved include: i) Internet of Things for Mobile Healthcare; ii) Improving Robots: Teleoperation and Haptics; iii) Nanoindentation response of Ti1-x Alx nanolayered coatings: An atomistic study; and iv) Smartphone based Indoor-Outdoor Micro-localization. During the research portion of the program, each participant worked closely with the respective engineering faculty to clearly articulate the goals and expectations, monitor the daily and weekly progress, and seek assistance as necessary. To accomplish the tasks set forth, participants were provided extensive assistance not just by the engineering faculty, but also by the engineering students. Once the initial research training of the participants was completed (mostly by end of the second week), teams focused on their own research projects. Although each project had its own challenges, participants dealt with several engineering related researching problems that can be listed as 1) process optimization, 2) circuit design and testing, 3) manufacturing tolerances, 4) literature reading and surveying, and 5) advanced engineering software usage for material characterization.

3. Engineering Faculty Mentored Research Projects

3.1 Internet of Things for Mobile Healthcare

The Internet of Things (IoT) has been gaining attention lately. The concept of the IoT uses electronic devices that capture/monitor data, connects the data to a private or public cloud, and enables automatic triggers for certain events. The many uses of the systems and products that connect to the IoT are changing healthcare. Patients and hospitals both stand to benefit from IoT. IoT applications in healthcare include mobile medical applications or wearable devices that allow patients to capture their health data. Hospitals use IoT to keep tabs on the location of medical devices, personnel, and patients. In this project, a complete IoT platform for smart healthcare will be designed. The project allows Arduino and Raspberry Pi users to perform biometric and medical applications where body monitoring is needed by using 10 different sensors: pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometer), patient position (accelerometer) and muscle/electromyography sensor (EMG). This information can be used to monitor in real time the state of a patient or to get sensitive data in order to be subsequently analyzed for medical diagnosis. Biometric information gathered can be wirelessly sent using any of the 6 connectivity options available: Wi-Fi, 3G, GPRS, Bluetooth, 802.15.4 and ZigBee. Data can be sent to the Cloud in order to perform permanent storage or visualized in real time by sending the data directly to a laptop or Smartphone.

3.2 Improving Robots: Teleoperation and Haptics

This project is composed of two areas, both dealing with human-robot/computer interaction. For each, we have a human-subject experiment prepared and had the participants finalize the experiment, build an apparatus, proctor the experiment, and analyze the data. The first experiment aims to make teleoperation better. Teleoperation is the control of a robot from a distance, usually via joystick and video feedback. Teleoperation is challenging, mentally tiring, and prone to long task times. This is partly due to hand-eye misalignment. This study will investigate the effect of simulated rotation (via computer graphics on a single monitor) and physical rotation (two monitors rotated physically) on the teleoperator’s performance.

The second experiment aims to better understand how humans touch (“haptics”) with their fingertips, important for applications such as touchscreens or virtual reality. This study will investigate the effect of touching speed on the ability of humans to discriminate stiffness differences between two computer-generated virtual surfaces.

3.3 Nanoindentation response of Ti1-x Alx nanolayered coatings: An atomistic study

Engineered hard coatings enhance surface properties such that structures become more stable in harsher environments and tougher against sudden impacts. However, such hard coatings are extremely sensitive to brittle fracture. To mitigate this problem, multilayer self-healing ceramic coating, such as Ti1-xAlxNy, Ti1-xCrAlxNy etc., are used to enhance strength and crack-healing performance. The purpose of this research is to investigate nanoindentation response of Ti1-x Alx nanolayered coatings using atomistic simulation technique. The goal is to properly understand the underlying nanoscale deformation mechanisms, as well as defect structures, to relate with the observed mechanical properties of such coating structures. The fundamental knowledge obtained at the nanoscale will be the key to developing a more complex coating structure at a larger scale via experimental techniques for crack healing applications.

3.4 Smartphone based Indoor-Outdoor Micro-localization

Smart devices are becoming more common in our daily lives; they are being incorporated in buildings, houses, cars, and public places. Moreover, this technological revolution, known as the Internet of Things (IoT) combined with advancement in smartphones brings us new opportunities. While a variety of assistive devices have been developed for the blind, much work is yet to be done in the areas of indoor/outdoor localization and navigation. Building upon this technological advancement and need for assistive devices, this project focuses on the design and implementation of a portable Smartphone and haptics-based localization and navigation system. The system consists of an array of ultrasonic sensors that are mounted on a waist belt to survey the scene, iBeacons and a Smartphone with embedded sensors to localize the user, and an array of vibration motors to provide haptic feedback to the user. The iBeacons will be deployed at different locations with each having a unique ID. In the cloud, there is a database for all the iBeacons attached with the corresponding information e.g. address and information about the place. The Smartphone detects the iBeacon's ID and sends it to the cloud, accordingly the cloud sends back the information attached to this ID to the Raspberry Pi that converts the text to audio and plays it via a Bluetooth headset to the user. While at the same time, the ultrasonic sensors detect obstacles in the path of the user and provide haptic feedback so as to allow the user navigate around the obstacles.

4. Preliminary Program Assessment

Project leadership communicated regularly via phone and email with the SAMPI external evaluators. Evaluation instruments, including a pre- and post-survey of summer program participants and an end-of-session questionnaire for secondary students who attended STEM Day, were developed cooperatively between the project leaders and the SAMPI evaluators.

All planned activities took place as scheduled, including the six-week summer program (July 11, 2016 – August 19, 2016), the Student STEM Day (November 4, 2016), and the first quarterly meeting of the research groups (November 18, 2016). The external evaluator from SAMPI attended and observed the first and last day of the summer program, the annual STEM Day, and the first quarterly meeting of the five research groups.

Five in-service teachers, five pre-service teachers, five community college instructors, and five undergraduate engineering students were recruited to participate in the project. One community college instructor dropped out after attending the first week of the six-week summer program. One of the five research teams, therefore, did not collaborate with a community college instructor, which caused one in-service to express disappointment on the post-survey: "We lost a member, which was sad."

4.1 Participant Post-Survey

SAMPI administered an online post-program survey to the participants on the final day of the summer program (August 19, 2016). The survey was designed to discover their perspectives on the various program components and impacts. The following is a preliminary analysis of the data; more detailed findings are available in a separate report.

All but two participants (one in-service teacher and one pre-service teacher) stated that the program met or exceeded their expectations. The in-service teacher whose expectations were not met explained, “I was hoping for more teacher-led discussions and topics that we were interested in.” The pre-service teacher remarked, “I was hoping for a bit more formal engineering training besides just hands-on experiences. I was hoping for just one tiny lecture about engineering, but never received it.”

Several participants identified ways they will be able to use what they learned through their summer program experience. Three pre-service teachers reported that they will incorporate the engineering process and problem-solving into their future classes. Two in-service teachers said their RET experiences would change the way they teach, including one who would “engage students in more exploration.” Two community college instructors stated they would incorporate aspects of what they learned into their college course curriculum.

Participants believed their RET experiences would have an impact on student achievement. In-service teachers intended to provide their students with more opportunities for exploration or reflection, and felt they were more able to help struggling students. Pre-service teachers stated they were better equipped to help students connect concepts to the real-world, and that their increased confidence would transfer to students. Community college instructors reported increased skills for helping students solve problems and think like engineers.

Participants were asked to identify the primary personal or professional benefit they received from their RET experiences. Four (including three pre-service teachers and one in-service teacher) identified opportunities to network, connect, or learn with other teachers. Other benefits included:

- Exposure to engineering.
- A research experience in engineering.
- How to implement engineering into the classroom/curriculum.
- Seeing the connection between engineering and other areas of science.
- Increased confidence.
- Greater understanding of what students find challenging.
- An in-depth look at the Next Generation Science Standards.

Participants identified numerous “big ideas” they learned from the program, the most common being that it is important to connect concepts to real-world examples. One pre-service teacher remarked that this is essential if one is to make “successful” lessons. Other “big ideas” included:

- Anyone can be an engineer.
- Science is social.
- You don’t always get the result you thought you would.
- It is important to collaborate or work with others to solve problems.
- Students should do more reflection or less memorization.
- We shouldn’t be afraid to try new things or “dream big.”

The primary challenge reported by pre-service teachers was their lack of background knowledge or experience:

- "Learning new materials was a challenge; I was not sure what to expect."
- "The expectations of the project was way over the skill level I was able to reach. It just simply was too advanced."
- "It was hard to help come up with a design with no engineering experience."

Three in-service teachers and one community college instructor were dissatisfied by a perceived lack of relevance. This included one in-service teacher who said the research project "was long and boring and not that useful in my learning" and another in-service teacher who felt the project had "zero transfer into my classroom." The community college instructor felt the program was not "specifically directed at issues in a community college."

One community college instructor was challenged by the timeframe of the program: "Six weeks is a long time. It is difficult to keep up the morale for the entire program, and we can run into some bumps along the way." However, this appears to have been an exception, as similar concerns were not expressed by other participants.

4.2 Student STEM Day Questionnaire

One hundred forty-one (141) of the 180 middle and high school students who participated in STEM Day activities completed a post-program survey. The survey contained ten rated items about their attitudes toward engineering, interest in an engineering career, and impacts of their experiences with STEM Day. The following is a preliminary analysis of the data.

Students were asked to rate their agreement with three statements about engineering (Table 1). They used a 5-point scale, with 1 = Strongly Disagree, 2 = Disagree, 3 = Not Sure, 4 = Agree, and 5 = Strongly Agree. Most agreed (rating of "4" or "5") that they liked creating or building things (n = 113, 81%), and the majority agreed engineering would help them in daily life (n = 85, 60%). However, a majority remained unsure or didn't think (rating of "1," "2," or "3") they would enjoy an engineering job (n = 82, 59%).

Table 1. Statements about Engineering.

	No. of Responses					**n**	**Mean**	**SD**
	1	**2**	**3**	**4**	**5**			
I like to create or build things.	2	7	18	53	60	140	4.16	0.93
Engineering will help me in my daily life.	2	12	42	54	31	141	3.71	0.96
I would enjoy a job that involved engineering.	6	17	59	20	38	140	3.48	1.14

Students were asked to rate the degree to which they could imagine working in a job where they design and build technologies that help people or protect the environment (Table 2). They used a 5-point scale, with 1 = Strongly Disagree, 2 = Disagree, 3 = Not Sure, 4 = Agree, and 5 = Strongly Agree. Slightly over half of the students (rating of "4" or "5") could imagine doing both (n = 77, 55%). This is more than those who stated they would enjoy an engineering job (Table 1; n = 58, 41%), suggesting that some students did not see a connection between "designing and building things" and "engineering."

Table 2. "I can imagine myself working in a job where I can…"

	No. of Responses					n	Mean	SD
	1	2	3	4	5			
Design and build technologies that help people.	5	19	39	41	36	140	3.60	1.12
Design and build technology to protect the environment.	5	14	43	42	35	139	3.63	1.08

Students were asked to rate their agreement with several statements about the impact of STEM Day (Table 3). They used a 5-point scale, with 1 = Strongly Disagree, 2 = Disagree, 3 = Not Sure, 4 = Agree, and 5 = Strongly Agree. Overall, the majority of students agreed with all five statements. Most (rating of "4" or "5") felt STEM Day helped them realize engineering could be interesting (n = 112, 79%) and that math and science are important (n = 100, 71%). Slightly over half were thinking about an engineering career more than before (n = 75, 53%) or learned about career opportunities they didn't know about before (n = 70, 51%).

Table 3. Statements about the Impact of STEM Day

	No. of Responses					n	Mean	SD
	1	2	3	4	5			
STEM Day helped me realize that engineering could be interesting	5	6	18	68	44	141	3.99	0.97
My knowledge of engineering grew because of STEM Day.	5	13	39	48	36	141	3.69	0.97
I learned about career opportunities that I didn't know about before.	4	27	37	44	26	138	3.44	1.09
I'm thinking about an engineering career more than I was before.	11	27	28	42	33	141	3.42	1.25
STEM Day helped me realize that the math and science are important.	4	6	31	40	60	141	4.04	1.04

4.3 Evaluator Comments

The comments and suggestions that follow are intended as topics for discussion as the management team reviews accomplishments and plans for the future. They are based on a review of and reflection on what has been learned about CMU-RET by evaluators during the first year of the project.

- The project directors have assembled a team of well-qualified educators and researchers to carry out this program. Several team members were involved in a previous RET grant at CMU (2012-15).
- The first year has been a productive time devoted to planning, organization, and implementation of the CMU-RET project goals and objectives.
- A strong atmosphere of cooperation characterized the relationship between the CMU project management team and the WMU evaluation team. Regular communication took place via

telephone and email. Both teams collaborated to create the pre/program surveys for summer program participants and the end-of-session questionnaire for the middle and high school participants of STEM Day.

- Project leadership successfully recruited five in-service teachers and five pre-service teachers to participate in a six-week summer program that included professional development and a research project led by an engineering faculty member and assisted by an undergraduate engineering student. Five community college instructors were also recruited, but one other dropped out after a week. Project staff may wish to consider creating an "alternate" list of participants who can be called upon if this happens again next summer.
- Project leadership also successfully implemented a Student STEM Day at CMU that mimicked the engineering design process. One hundred forty-one (141) middle and high school students attended the event. The experience caused half of them to think more about an engineering career than they were before.
- Most of the summer program participants valued the research experience they received through the program, although three in-service teachers and one community college instructor had difficulty seeing its relevance to their learning or teaching. Project leadership is encouraged to look into possible reasons for this lack of clarity. Perhaps participants will receive clarity as they participate in school year follow-up activities such as Quarterly Team Meetings.
- Pre-service teachers were challenged by their lack of background knowledge. The evaluation team suggests providing them with at least some formal training before placing them in a research setting. For example, a session could be designed for the first day of the workshop to introduce pre-service teachers to essential engineering concepts. As one pre-service commented on the post-survey, "I was hoping for just one tiny lecture about engineering, but never received it."
- Overall, project leadership has made a good start on not only working on the project goals and objectives but also on implementing Year 01 activities. The evaluators are encouraged by the preliminary findings outlined in the previous section of this report, appreciate the cooperative environment, and look forward to continuing to work with the CMU project team.

5. Conclusion

The preliminary implementation of NSF RET program at CMU has proved to be an effective professional development program for community college faculty, in-service and pre-service teachers. Based on the feedback obtained during the program, it could be stated that the RET program has been effective for engaging participants in meaningful engineering research experiences that allowed them to gain exposure to engineering concepts, and the process behind. Participants were able to contribute to the overall research goals and were able to complete a small research project. This learning experience combined with the academic year coaching helps them enhance their respective classroom curriculum.

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References

[1]. President's Council of Advisors on Science and Technology. (2010). Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future.

[2]. National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.

[3]. Kimmel. H., Carpinelli. J., Burr-Alexander. L., Rockland. R. (2006). Bringing Engineering into K-12 Schools: A Problem Looking for Solutions, American Society for Engineering Education Annual Conference & Exposition.

[4]. Guskey. T. (1986). Staff Development and the Process of Teacher Change, Educational Researcher, 15, 5-12.

[5]. Joyce. B, Showers. B. (1988). Student Achievement through Staff Development, Longman.

[6]. Garet. M. S., Porter. A. C., Desimone. L., Birman. B. F., Yoon. K. S. (2001). What Makes Professional Development Effective? Results from a National Sample of Teachers, American Educational Research Journal, 38(4), 915-945.

[7]. Bransford. J., Brown. A., Cockings. R. (2000). How People Learn: Brain, Mind, Experience, and School, National Academy Press.

[8]. Yoon. K. S., Garet. M., Birman. B., Jacobson. R. (2006) The Effects of Mathematics and Science Professional Development on Teachers' Instructional Practice: Using Professional Development Activity Log, Council of Chief State School Officers, Washington, DC.