First Year Experience of Running the Research Experience for Teachers in Alternative Energy and Automotive Engineering Program

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First Year Experience of Running the Research Experience for Teachers (RET) in Alternative Energy and Automotive Engineering Program

Abstract

The School of Engineering and Computer Science at Oakland University was awarded by the National Science Foundation a grant entitled "Research Experience for Teachers in Alternative Energy and Automotive Engineering: Energize K-12 Teaching and Learning." This is a three year program starting on Oct 1, 2015. The objective of the proposed RET site is to strengthen K-12 education in the Science, Technology, Engineering and Mathematics (STEM) disciplines by each year involving around 12 middle and high school science and mathematics teachers and pre-service teachers from the metro-Detroit area in multidisciplinary and cutting edge research on alternative energy and automotive engineering for 6 weeks during the summer at Oakland University (OU). In the past summer, a total of 11 teachers have taken part in the RET program at Oakland University. This paper will focus on the organization of this program including recruitment, on-site activities and program assessment. Also, the lessons learned from running this type of program will be summarized. Some suggestions to keep the sustainability of the program will be also provided.

Introduction

The effects of globalization on science, engineering and manufacturing have been particularly felt in rust-belt states such as Michigan and everyone in these areas can remember the impacts that the 2008 economic downturn had on industry and the economy. Thankfully, manufacturing industries such as those from the automotive sector have recently experienced renewed vigor and growth, particularly in southeastern Michigan, where Oakland University (OU) is located (in a hub of automobile makers and automotive suppliers). There is tremendous enthusiasm and need to develop the capacity to innovate in the areas of clean energy and alternative propulsion systems. In fact, according to some of the newest payroll survey data from the Bureau of Labor Statistics, Michigan is among the top 5 states that had the highest job growth rates in the period of June 2009 to November 2013 [1]. Yet, the engineers of the future are now students in schools who require *inspired* and *inspiring* K-12 school teachers who themselves have firsthand knowledge of engineering and the new technological developments that hold promise to address the tremendous challenges facing our state and nation. It is increasingly clear that teachers have profound and lasting impact on students' learning. However if K-12 teachers are to help prepare the engineers of tomorrow, they themselves need to be supported to have their own experiences in engineering and to develop ways of bringing that knowledge back into the classroom.

This awarded NSF Research Experience for Teachers Program at Oakland University aims to bring the excitement and knowledge developed in engineering research from the lab into the classroom so that teachers can move their students to envision engineering as an attractive and important career opportunity.

It is our belief that in order for such an RET program to be successful, it must have substantial involvement by people with first-hand knowledge of pedagogy and teacher training, i.e., faculty from the School of Education and Human Services. Recent scholarship on how students best learn science and mathematics [2] demonstrates that powerful understandings are generated when students learn how to make hypotheses, devise and test questions, and then interpret and substantiate claims with data. However, studies also suggest that secondary teachers have difficulty in both understanding and enacting inquiry practices in their classrooms [3-5] and that research experiences can address and mediate these concerns [6]. This is particularly significant for students from under-represented groups – the main focus of this RET program - because traditional STEM instructional approaches, such as lectures, may impede learning opportunities for students who do not share mainstream linguistic backgrounds [7]. Project based learning is considered more equitable because content knowledge is both more experiential, and also because the explicit effort to make connections between claims and data results in a more powerful learning experience for all students. If under-represented students gain access to more powerful learning experiences—their chances improve that they may pursue opportunities for careers in STEM disciplines. The key levers in this argument are the roles played by the teacher and the powerful experiences they have with engineering through projects such as the RET [8] and how teachers are supported to translate such experiences into classroom contexts [5, 9]. This program directly addresses these elements.

This paper will focus on the organization of this program including Application and Recruiting, Program Structure and Activities and Program Assessment. Some suggestions to keep the sustainability of the program will be also provided.

Application and Recruiting

The program ran for the first time for six weeks in the summer of 2016 between June 29 and Aug 10. The NSF RET flyer was prepared in Dec 2015, and sent out though our school outreach director and Faculty members from both the School of Engineering and Computer Science and the School of Education and Human Resource. The program announcement has reached to the in-service teachers from six different school districts in the Southeast Michigan and the pre-service student teachers at Oakland University. A website [10] was designed to promote the program and an on-line application system was created for the convenience of application. The program deadline was the end of February when most of local schools started their winter break. The applications include a background questionnaire, a statement of interest, information regarding engineering/science background and courses taught or developed, and two letters of recommendation. The selection of the participants was based on the following criteria:

1. Examination of applicant's resume by the PIs and senior personnel participating faculty with input from our K-12 educational partners;
2. Consideration of applicant's letter(s) of recommendation;
3. Consideration of applicant's statement describing the reason for his/her interest in participation in this program, in addition to his/her commitment to seeing this program through the summer and into the classrooms;
4. Consideration of applicant's mentoring history in the classroom, including developing innovative teaching methods in STEM fields, leadership in after-school STEM

activities, encouragement of students to participate in external outreach programs (for in-service teachers only).

5. Additional consideration of GPA (>3.0) for pre-service teachers, their extracurricular involvement, and their plans of teaching STEM after graduation.

We received a total of 23 applications including one pre-service teacher. Eleven teachers have been selected as final candidates to participate in the RET program at Oakland University. An acceptance letter was sent to the candidates, and all the candidates returned the signed letter within a week. Table 1 shows the profile of teachers selected for the 2016 summer program.

Table 1: 2016 RET Teachers' Profile

Applicants (F/M)	School District	School Level	Teaching Subject	Years of Teaching
1 (F)	Avondale	High School	Math	10
2 (M)	Avondale	Middle School	Science	6
3 (F)	Novi	High School	Physics	7
4(M)	Birmingham	Middle School	STEM	21
5(F)	Oakland University	High School	Chemistry	Pre-service
6(F)	Utica	High School	Math	15
7(F)	Avondale	Middle School	Science	17
8(M)	Utica	High School	Math	10
9(M)	Pontiac	High School	Science	14
10(F)	Lake Orion	High School	Physics	10
11(M)	Oak park	High School	Science	20+

Note:

Oak Park High School: 95% minority student population which borders the city of Detroit

Pontiac School district: 64% African-American and 19% Hispanic, a public school district that serves primarily minority students in the Greater Detroit area;

Avondale School District: Minority enrollment is 41% of the student body (majority African-American), which is more than the Michigan state average of 32%.

Among the 11 RET teachers, five of them are from the school districts which serve primarily minority students. For example, the Oak Park High School has 95% minority students which live in the city of Detroit; the Pontiac school district has 64% African-American and 19% Hispanic students in the Greater Detroit area; the Avondale School District has 41% minority enrolment. Among the 11 RET teachers, three of them are middle school teachers, and the rest are high school teachers. The teacher's teaching subject varies from Math, Science, Physics, Chemistry and STEM. Three teachers teach Math, four Science, two Physics, one Chemistry, and one STEM. Most of teachers are in their middle of career (10+ years of teaching experience), two teachers have 20+ years' experience, and three has less than 10 years of teaching experience. Six teachers are female. Only one pre-service teacher was selected.

Program Structure and Activities:
Each RET teacher received a $6,000 (in-service) or $4,200 (pre-service) stipend and a small meal allowance. Each teacher also has up to $2,000 for material supplies for the course module developed as a result of RET program.
Emails have been sent out to the interested faculty in April to ask about their interests in supervising the RET teachers in the summer. Ten of them responded with a short description of the research project. Considering the difficulty level of different research projects, the RET teacher's interest, and the availability of the faculty, only four faculty members were selected for the summer of 2016. Some faculty will be available in the summer of 2017. One faculty member is from the Department of Electrical and Computer Engineering and the other three faculty members are from the Department of Mechanical Engineering. All research project topics were discussed in pre-program meetings with the faculty advisors to ensure that they were doable for RET teachers. Each faculty presented their research project to the RET teachers in the second day of the program, and each teacher ranked the project based on their interest and their background. Then the teachers were paired in a group of two to three person based on their preference. Even though every teacher selected their preferred topic, many indicated that they were flexible with the project assignment. The four research topics in summer 2016 are

1) Measuring in-Plane Thermal Conductivity of a Li-ion battery.
2) Friction of Steel and Aluminum with Graphene Nanolubricant.
3) Construction and Improvement of a Fly Eye Vision Sensor.
4) Determining Thermal Characteristics of New Composite Materials.

All these topics are related to automotive engineering or alternative energy. Topic 2 is the most liked topic since it is closely related to the physics curriculum. The other three topics received equal attentions. RET teachers worked in teams on their respective research project. Each team has both one faculty member and one graduate student as mentors. The mentors met regularly with the RET teachers.

Besides research activities in the research lab, the faculty member from the School of Education and Human Resources offered a project-based learning workshop each Thursday. This aims to help the RET teachers to transform what they have learned from the research project to the knowledge in the classroom. They also learned the method of course module design. With the help of workshop, most of RET teachers have submitted a course module (or draft) by the end of summer.

In the final day of the program, each group gave an oral presentation for the research project they have been working on. They also presented the course module plan derived from the research experience during the summer. During the lunch time, the group made the poster presentation. OU professors, students, teachers, industry mentors, and administrators from high and middle schools attended the presentation.

Table 2 summarizes the schedule of program activities. These activities include the program orientation, research and teaching seminars, workshop training, literature training, the industrial site visit and final project presentation.

Table 2: Program Activities Highlights

Time and Date			Topics
Week 1	Day 1	9:00am-10:00am	Orientation: Program overview & Expectation; Project Presentation.
		10:00am-10:30am	Pre-Program Survey
		10:30am-12:00am	Campus Tour and Lab Tour Paper work and ID pickup
		12:00am-1:30pm	Lunch (Group lunch)
		1:30pm	Seminar on Literacy (seminar)
		2:30pm	Outreach program introduction
	Day 2	9:00am-12:00am	Research Project Presentation
		1:3opm	Machine Shop Training Lab Safety Training
	Day 3	9:00am-3:00pm	STEM Best Practice Workshop Dr. Chris Kobus, Dr. Mark Olson and Ms. Marianne Donoghue) (EC 275)
Weeks 2-6	Monday-Wednesday, Friday		Research Project in the research lab
	Wednesday 10:00am-12:00am		Technical Seminars 1) Alternative Energy;(Week2) 2) Automotive Engines (Week3) 3) Fuel Cells and Batteries (Week4) 4) Hybrid and Electric Vehicles(Week 5)
	Thursday (9:30-3:00pm)		Course Module Development; Meet with Education Advisor; Course module Seminar (Project Based Learning and Transfer research experience into classroom workshop)
	Friday		GM Battery Lab Visit (Week5)
	August 10 (last day)		Project presentations, reports detailing projects and module classroom development, debriefing, conclusions Focus Group (Program assessment)

Assessment

The RET program was assessed in a number of ways: Pre-RET and post RET surveys along with focus groups were conducted to assess the expectations of the teachers, their opinion and belief about engineering, and their level of satisfaction with different aspects of program. Dr. Anica Bowe, the program assessment coordinator, along with the PI, visited a few classrooms taught by the RET teachers to determine the impact of the RET program on students' thinking. This study

presents select findings from the teacher self-efficacy in engineering pre-post survey. A more comprehensive report of findings will be completed at the end of the academic year when all data have been collected.

Pre-RET Surveys: At the initiation of the 2016 summer program, teachers (n = 10) completed a comprehensive survey on their beliefs and practices regarding STEM teaching and student learning so the evaluator could gauge teachers on their general dispositions towards STEM teaching. Teachers also completed pre-surveys on their self-efficacy for teaching engineering (n= 10). After the completion of the summer program, teachers completed a post-survey (n =7-8) on their self-efficacy for teaching engineering during the Fall to measure any perceived changes in beliefs as a result of the summer program. The results of the pre-post survey are found in Table 3.

Table 3: Teachers reported self-efficacies in teaching engineering pre-post summer program.

		Strongly Disagree	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
1. I can discuss how given criteria affect the outcome of an engineering design project.	PRE N=10	20%	10%	20%	0%	40%	10%
	POST N=8	0%	0%	0%	25%	50%	25%
2. I can assess my students' engineering design products.	PRE N=10	10%	30%	10%	20%	10%	20%
	POST N=8	0%	13%	0%	25%	63%	0%
3. I can craft good questions about engineering for my students.	PRE N=10	10%	10%	20%	10%	20%	30%
	POST N=7	0%	0%	0%	0%	71%	29%
4. I can employ engineering activities in my classroom effectively.	PRE N=10	20%	10%	10%	20%	30%	10%
	POST N=7	0%	0%	0%	29%	57%	14%

5. I can discuss how engineering is connected to my daily life.	PRE N=10	0%	10%	20%	30%	20%	20%
	POST N=7	0%	0%	0%	0%	43%	57%
6. I can spend the time necessary to plan engineering lessons for my class.	PRE N=10	20%	0%	20%	0%	30%	30%
	POST N=7	0%	0%	0%	57%	43%	0%
7. I can recognize and appreciate the engineering concepts in all subject areas.	PRE N=10	10%	0%	20%	40%	20%	10%
	POST N=7	0%	0%	0%	14%	86%	0%
8. I can guide my students' solution development with the engineering design process.	PRE N=10	10%	20%	10%	20%	20%	20%
	POST N=7	0%	0%	0%	0%	100%	0%
9. I can gauge student comprehension of the engineering materials that I have taught.	PRE N=10	10%	0%	10%	50%	20%	10%
	POST N=7	0%	0%	0%	14%	72%	14%
Note. All percentages are within rounding.							

At the pre-survey, teachers demonstrated a range of self-efficacies for factors related to teaching engineering. At least 50% of the teachers reported that prior to the summer program, they moderately/strongly agreed that they could lead discussions on engineering criteria (item 1), craft good questions related to engineering (item 3), and that they had the curricula time to plan engineering lessons (item 6). Areas teachers reported having the least self-efficacy were in assessing engineering design produces (item 2), effectively lead engineering activities (item 4),

and lead discussions on engineering criteria (item 1), as at least 30% of teachers reported that they strongly/moderately disagreed to these items. The fact that item 1 shows up both times suggests that this skill might be one of the more polarizing skills related to teaching engineering.

On the post-survey, teachers demonstrated an increase in self-efficacy in all areas measured. In fact, the only item that teachers expressed a level of disagreement was item 2, "I can assess my students' engineering design products". For that item, one teacher said that they slightly disagreed with that statement. From a perusal of table 1, it appears as if teachers made the most growth in self-efficacy for items 3 (I can craft good questions about engineering for my students), 5 (I can discuss how engineering is connected to my daily life), and 8 (I can guide my students' solution development with the engineering design process).
Based on the results of the pre-post teacher survey for teaching engineering, we can infer that the summer RET program was effective in increasing teacher self-efficacy in teaching engineering.

Conclusions

The program ran successfully even though that it was the first year of running the program. A total of 11 teachers have been involved in four different research projects related to alternative energy and automotive engineering. A series of activities have been organized to promote the learning and teaching of various engineering subjects. The teachers have demonstrated an increase in self-efficacy in all areas of program outcomes. They have expressed greatest satisfaction to the program overall. We will continue the follow-up visits for the next two years to help with the implementation of the course module in the classroom.

We have conducted the program evaluation, and the RET teachers are all very satisfied with the activities of this program. The only thing we need to improve is that they wish that they could have more time to conduct research. Since the program is designed for six weeks only, we plan to send the research projects to the RET participants a little bit earlier this year so that they can have some project background before they get started.

We plan to invite three of the last year's RET teachers back this summer. In this way, we will call them RET fellows. They can continue to work on the previous project or join in a new project team. They can help with mentoring the new RET teachers. They can also share the experience of course module development and implementation, which is believed to benefit the RET teachers to a great extent.

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