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Lessons Learned from Year 1 of NSF Research Experience for Teachers Site at North Dakota State University

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Abstract

A new Research Experience for Teachers (RET) site was established in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University (NDSU) with funding from the National Science Foundation Division of Engineering Education and Centers (NSF Award #1953102). The site focused on civil engineering instruction around the theme of mitigating natural disasters for secondary education (6^{th} to 12^{th} grade) teachers. Eight local teachers and one pre-service teacher (who comprised the first cohort) were provided with a six-week long authentic research experience during the summer, which they translated into a hands-on curriculum for their classrooms during the 2021-2022 academic year. Partnerships were developed between the host institution, area teachers and local partners from civil engineering industries. This paper will summarize the lessons learned by the authors as well as the effectiveness of the program activities to accomplish two objectives: (1) provide a deeper understanding of civil engineering and (2) develop better abilities among secondary education teachers to prepare future science, technology, engineering and mathematics (STEM) leaders.

Several strengths were identified by the authors as they reflected on the summer activities including the successes in creating strong connections between the teachers, faculty members and graduate students, and the industry partners as well as the agility of the core research team to overcome unexpected challenges. However, the reflections also revealed several areas for improvement that would increase the accessibility of the site to underserved and/or underrepresented teacher populations, better utilize the resources available and in general, improve the quality of the program and curriculum developed by the teachers. Included within this paper are suggestions that the authors would make to improve current and future RET sites.

All of the teachers agreed or strongly agreed that their participation in the RET program increased their knowledge of STEM topics and specifically, civil engineering topics. The participants agreed to varying extents that they will use the information they learned from the program to teach their students and will implement the new strategies they gained to promote increased student learning about STEM topics. Furthermore, the feedback that they provided corroborated some of the same changes the authors plan to implement.

Introduction

With funding from the National Science Foundation Division of Engineering Education and Centers under Award #1953102, a Research Experience for Teachers (RET) site was established at North Dakota State University (NDSU) by the PI and Co-PI (herein, the RET team). The RET site in the Department of Civil and Environmental Engineering (now Civil, Construction and Environmental Engineering or CCEE) intends to increase the knowledge of secondary (6^{th} to 12^{th} grade) teacher participants on ways that civil engineering is being used to mitigate natural disasters in the Midwest region and around the world. The selected teacher participants engaged

in hands-on research under the mentorship of CCEE faculty and activities organized by the RET team to help them translate their research experiences into improved secondary STEM curriculum for their classrooms [1] – [3]. Two goals were created to achieve this objective. The first is to develop tangible hands-on curriculum that the teachers may use to foster better understanding of civil engineering in their classrooms, while the second is to improve the ability of secondary teachers to prepare their students to become the future leaders in STEM fields.

Due to the ongoing COVID-19 pandemic, the first cohort of teachers were recruited from school districts within a commuting distance from NDSU. It should be noted that these districts serve a large population of underserved and/or underrepresented groups in engineering including women, Hispanics, African Americans, and Native Americans. To allow for authentic connections between the research and the resulting curriculum, teachers were required to teach in a STEM or STEM-related field. Pre-service teachers from the NDSU School of Education were also encouraged to apply. The RET team intentionally paired pre-service teachers with current teachers in order to (1) build a mentoring relationship that could provide support for the pre-service teachers and (2) identify a classroom for the pre-service teachers to teach the curriculum that they helped to developed.

The teachers were assigned to faculty mentors from the CCEE Department. The faculty were selected based on their interest in the program, which they indicated by submitting a short abstract describing a research project along with the responsibilities that would be assigned to the teachers. Each abstract was required to be connected to the theme of mitigating natural disasters. The faculty and projects selected for the RET site during its first year represented a diverse population and wide spectrum of the civil engineering subdisciplines (namely, geotechnical, transportation, environmental and structural engineering).

Research activities were not strictly governed by the RET team outside of the requirement that they must be hands-on and connected to the theme. The RET team primarily focused on assisting the teachers to translate their hands-on research experiences into tangible curriculum for their students and on activities that would foster cohort development among the teachers. Cohort development began on the first day of the summer program through team building activities and discussions that engaged the participants along with the graduate students and faculty mentors involved. These efforts were continued in weekly lunches that encouraged the discussion of research activities and their curriculum ideas among the teachers and served as a time to address any questions or concerns that they had. Organic relationship building was promoted by providing coffee and snacks throughout the day in a central workroom. The success of these activities was evident at the end of the summer program in the capstone presentations through the encouragement provided and collective sharing of ideas that occurred as well as by the participant responses in the post-experience survey.

This paper will briefly summarize the lessons learned from the first year of the RET program at NDSU. In particular, it will focus on the strengths of the summer activities and identify areas of improvement while providing recommendations to current and future RET sites to aid in the success of their programs. While the majority of the paper will focus on the reflections from the

RET team, the impacts of the site on the teacher participants and their ability to teach STEM subjects will also be presented.

Teacher and Faculty Application and Selection Processes

Initial contact with the teachers to solicit applications was made in the form of an email message that was sent by school superintendents, other district administrators, principals and teachers in STEM departments. It was found that the lack of a first name connection with the superintendent's office in larger school districts by the teachers resulted in lower levels of interest in the program. This was not found to be an issue in smaller school districts where the email sent by the superintendent was successful in garnering interest for the program. The level of interest in larger school districts saw an uptick when principals and other teachers in STEM departments conveyed the same message.

The on-going and ever evolving COVID-19 pandemic had several impacts on the teacher recruitment process. Several interested applicants could not participate in the program as a result of being overcommitted or the possibility of having to make arrangements for their young children, particularly when their child's or children's daycare was closed. The additional demands placed on teachers due to the pandemic included the loss of preparatory periods, the lack of substitute teachers, etc. [4] resulted in many teachers feeling burnt out. These impacts tend to be amplified among individuals from underrepresented and/or underserved populations leading to further marginalization. Thus, it is recommended that RET teams consider summer programs that are more inclusive and allow for greater flexibility in the delivery of the program and are able to provide childcare.

Emails also served as the initial mode of contact to request faculty for summer projects and obtain faculty interest in the RET site. However, only one project proposal was a direct result of the email messages. The remaining project proposals stemmed from direct communications with faculty in hallways and other informal settings. Thus, it is recommended that future solicitations for faculty-led projects begin with an announcement at a faculty meeting with a follow-up email message containing additional details and instructions to submit summer projects.

Original plans for the RET site involved matching two teachers (one in-service and one pre-service) with one faculty mentor. However, other summer commitments by the faculty and COVID-19 burnout felt by the faculty made these plans difficult to implement. As a result, the RET team opted to allow faculty members to act as co-mentors jointly supervising the teachers in the research activities. Several direct benefits stemmed from this change in the structure of the RET site. First, co-mentors build redundancy in the RET program allowing teachers to have two individuals that they could interact with during the summer activities and for the future implementations of the curriculum that they developed. However, this also led to some confusion among the teachers and graduate students due to the lack of regular, effective communication between the co-mentors. A second benefit, the submitted project proposals naturally became more interdisciplinary and cross-disciplinary in nature while increasing their applicability to the secondary educational standards. Third, the differing levels of experience among the faculty co-mentors resulted in informal mentoring among the individuals involved.

Despite the challenges, the ratio of women to men participants at the NDSU RET site was larger than that of a typical civil engineering classroom. CCEE faculty submitted six project proposals of which one-third had a single faculty mentor and remaining had faculty co-mentors. Of the five projects selected, three had a woman faculty co-mentor. Thus, underrepresented and/or underserved teachers and faculty mentors were successful recruited by the RET team.

Summer Programming

Scheduled summer activities included two workshops led by the RET team for all of the participants. The first workshop focused on the research efforts providing participants with guidance on: (1) conducting a literature review, (2) formulating a research question and/or hypothesis, (3) describing the methods used, (4) effective presentation of the results and findings, (5) discussing their results, and (6) presenting their results via poster presentations. The second set of workshops focused on curriculum development with the intent of assisting the teachers to translate their hands-on research experiences into curriculum for their classrooms. Workshops were geared towards: (1) identifying applicable educational standards, (2) preparing pacing guides and "I can" statements, (3) writing daily lesson plans, (4) developing summative assessments and (5) peer reviews. Plenty of content was freely available to the RET team through various sources to support these workshops. However, the development of content specific to the site goals made it possible to focus on the essentials, allocating additional time to the participants to work on their deliverables for each workshop.

Each workshop had an associated deliverable intended to divide the major outcomes (a poster presentation about the research findings and a curriculum module related to the research activities) into a series of manageable tasks. However, the timely submission of these deliverables by the teachers posed an issue for the RET team often requiring one or in some cases, multiple, reminders before it was received. In future years of the site, the RET site will more closely link the stipend payments with the major deliverables as opposed to providing stipends based on percentage of participation in program activities.

Connections among the participants and the research team were encouraged through a cohort model. Cohort activities allowed teachers to learn about the career pathways taken by graduate student assistants and faculty mentors, which often linked past experiences to current research interests. It also provided the teachers, who were all CaucasianWhite, with different perspectives and trajectories that their students may follow in the future. Teachers noted that they planned to invite the graduate students and faculty mentors into their classrooms for guest lectures to allow their students the chance to interact with individuals from a variety of diverse backgrounds.

At the start of the summer program, the RET team did not allow time for informal interactions in the cohort activities. This oversight was evident in the first week of the program allowing the team to make corrections for the remainder of the program. The team quickly organized several social lunches for the teachers, graduate students and faculty mentors, but the turnout varied since many graduate students and faculty mentors had prior commitments. It is recommended that such activities be planned in advance and that faculty mentors and graduate student

assistants be notified of the required attendance at these informal events to create stronger connections with the teachers.

Teacher Perspectives

The teachers participating in the RET site at NDSU were given a pretest and posttest to better understand their knowledge and interest in teaching STEM topics. The posttest also sought to collect evaluation data regarding the impact of the RET program. The pretest was given as part of the orientation on the first day of the summer activities, while the posttest data was collected for a month after the completion of the summer activities. A total of nine participants completed the pretest yielding a 100% response rate, while eight participants completed the posttest for a response rate of 89%.

All of the teachers agreed or strongly agreed that their participation in the RET program increased their knowledge of STEM topics and, specifically, civil engineering topics. They agreed to varying extents that they will use the information they learned from the program to teach their students. The teachers also shared that they will implement the new strategies they gained during the RET program to promote increased student learning about STEM topics.

Qualitative feedback regarding the RET program yielded multiple comments that the most helpful aspect of the RET was working with other teachers. Others noted that they enjoyed having time to develop curriculum that will be used in their classrooms and that they learned more about becoming a civil engineer. The participants also provided recommended improvements to the RET program including, a need for better balance between the research and curriculum development with more time for curriculum writing. It was also noted that more interaction was needed with the faculty mentors. As such, the feedback they provided corroborated some of the same changes the authors plan to implement.

Recommendations for Future RET Programs

Based on the experiences of the RET team, the following recommendations are provided to future RET programs:

- When soliciting teacher applications via email messages, be cognizant of the communication chain. Name recognition of the individual sending the message will impact the number and quality of applicants received. While messages from superintendents in smaller school districts is effective, they may not be effective in larger school districts where principals or other teachers may be a better alternative.
- Faculty interest was successfully garnered through the use of personal communication rather than emailed requests. Faculty meetings may serve as a good forum for initial requests for proposals and mentors.
- Allowing faculty to co-mentor participants resulted in several benefits including additional support, more interdisciplinary and cross-disciplinary projects, and informal mentoring among faculty colleagues. However, additional guidelines are necessary to ensure regular and effective communication among the mentors that will reduce the potential confusion and some (if not, all) of the challenges.

- Consider developing workshop content that is focused on the site goals to reduce unnecessary information that is conveyed to the participants and allow a more streamlined effort to learn the research concepts and their translation into curriculum modules.
- Stipend payments should be linked with the submission of deliverables. This may result in more timely submissions and a greater response rate to reminders for late/missing submissions.
- Time for informal interactions via social events (for example, lunches) should be included in summer activities. Faculty mentors and graduate students should be notified early to allow them adequate time to ensure their presence.

Finally, sites should be aware of the challenges facing teachers and faculty as a result of the COVID-19 pandemic and the added burden placed on individuals from underserved and/or underrepresented populations. Efforts to provide more inclusive programming and greater flexibility in the planned activities are particularly encouraged to avoid the further marginalization of these populations.

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