PROJECT REPORT

STEM Teacher Leadership Development Through Community Engagement

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Abstract

Academic service-learning through community engagement in a museum provides an opportunity for teacher leadership development in science, technology, engineering, and mathematics (STEM) education. Twenty student volunteers from teacher education in a public university took part in service-learning teacher leadership activities in STEM education through a local museum. A preliminary analysis of student responses to self-reflection questions indicated emerging themes predominantly in the areas of self-confidence development and depth of understanding of the topic, followed by audience STEM learning and sense of self-responsibility. Plans for future direction are explored with implications for teacher leadership in STEM education.

Keywords: STEM education, preservice teacher leadership, community engagement, museum, informal science education, service-learning, efficacy, student volunteer

Introduction

This paper describes academic service-learning by student volunteers in teacher education through community engagement in science, technology, engineering, and mathematics (STEM) education in a museum, with a focus on developing teacher leadership. Calls for a workforce that is STEM skilled are being heard from leaders in business, government, and education. For example, the Committee on STEM Education of the National Science and Technology Council (2018) stated that "the nation is stronger when all Americans benefit from an education that provides a strong STEM foundation for fully engaging in and contributing to their communities, and for succeeding in STEM-related careers, if they choose.... Even for those who may never be employed in a STEM-related job, a basic understanding and comfort with STEM and STEM-enabled technology has become a prerequisite for full participation in modern

society" (p. 5). According to President Donald Trump, his administration "will do everything possible to provide our children, especially kids in underserved areas, with access to high-quality education in science, technology, engineering, and mathematics" (Office of Science and Technology Policy, 2018, n.p.). How to transform such reform calls into action in K–12 classrooms is an important question. This article draws attention to the connection between teacher leadership in STEM areas and the university experiences and opportunities of aspiring teachers. Specifically, does academic service learning in STEM through community engagement in a local museum develop teacher leadership skills?

Teacher Leadership

For the purpose of this study, teacher leadership in preservice STEM education is defined as follows: It is a process of developing leadership qualities (e.g., knowledge, dispositions, skills) in preservice teachers by engaging in volunteer activities that extend beyond classrooms into the community, tapping into local STEM resources (Ado, 2016; Bond, 2011; Teacher Leadership Exploratory Consortium, 2011; Center for Strengthening the Teaching Profession, 2018; Wenner & Campbell, 2018).

Bond (2011) in a review of teacher leadership recommended that preservice teachers be given opportunities to serve and learn through volunteer activities in their local communities. Ado (2016) suggested "improving outreach and collaboration with families and community" (p. 15) for teacher leadership development. On the other hand, in a study of teacher leadership, Ado (2016) noticed that unless prompted, preservice teachers failed to address "improving outreach and collaboration with families and communities" (p. 15) as part of teacher leadership development. It is a reflection of our present system of education and preparation of teachers, which does not value outreach and community engagement. The Teacher Leadership Exploratory Consortium (2011) and the Center for Strengthening the Teaching Profession (2018) have recommended that preservice and in-service teachers engage in outreach activities in their local communities as a part of the process for developing teacher leadership.

Classroom teacher efficacy is key to student learning in K–12 education (Hattie & Timperely, 2007) and teacher leadership impacts student learning (Stronge & Hindman, 2003; Kumar & Scuderi, 2000). Without teacher leaders in our schools who are well prepared and confident enough to lead the STEM education reform, calls for STEM reform may not come to fruition. Teacher leadership also has the potential to retain teachers through support as they enter the teaching profession and as experienced teachers. In his study, Buchanan (2010) found that "lack of support emerged as the single strongest predictor of a decision to leave the profession" (p. 205). According to Danielson (2006), "precisely because of its informal and voluntary nature, teacher leadership represents the highest level of professionalism. Teacher leaders are not being paid to do their work; they go the extra mile out of a commitment to the students they serve" (p. 1). Students in this STEM program volunteer and already represent a group of individuals who are willing to go the extra mile.

Carlone and Johnson (2007) identified three constructs that support the development of teacher leaders:

- **Competence** – knowledge and understanding supportive of leadership pursuits
- **Performance** – social performances of relevant teacher leadership practices
- **Recognition** – recognition by oneself and others as a teacher leader

In this context, an opportunity for undergraduate teacher education students to volunteer in a museum supports teacher leadership development in STEM education through community engagement. Students develop their STEM skills along with their leadership skills through deepening their content knowledge, participating in teacher leadership practices as presenters in the museum, and receiving recognition by others as leaders in the STEM topic they choose. Students have the additional opportunity to identify creative ways to tap into community resources, to enrich learning experiences for their students, to connect classroom lessons with STEM outside the classroom, and to serve as change agents.

Community Engagement

It was after the publication of the article titled "Opportunities for Teachers As Policymakers" (Kumar & Scuderi, 2000) that volunteer opportunities for teacher leadership development in informal STEM education through community engagement were created for Florida Atlantic University (FAU) undergraduate students in the course "Principles and Methods: K-9 School Science." In the era of applying business models to the administration of schools and colleges, teachers are told what to do rather than given the opportunity to be professionals capable of making independent professional decisions in educational settings. This is reflected in the National Survey of Science and Mathematics Education (NSSME+) in the United States (Banilower et al., 2018). According to this NSSME+ survey, less than half of science teachers engaged in leadership activities, and elementary science teachers (8%) were less likely to lead a professional learning community in science than their high school peers. In this context, instilling in teachers, especially those in training, the confidence of leadership is essential if true education reform is the goal of the myriad of reform calls in STEM education (Kumar, 2019).

Discovery centers, planetariums, afterschool centers, and museums are excellent resources for community-based STEM education in the context of the real world. According to NSSME+ (Banilower et al., 2018), about 28% of elementary classes and 49% of high school classes have based their science instruction on lessons and units collected from sources such as museum partners, conferences, or journals, etc., rather than on traditional textbooks. Commercial textbooks published by the Museum of Science, Boston, are used in 4% of elementary classes. The survey also shows that only about 3% of elementary school students in self-contained classes have received science instruction from "someone outside the school," such as a staff person from a local museum, though 68% of elementary schools and 78% of high schools encourage students to attend summer camps organized by science centers or museums.

In order to tap into informal educational institutions in communities across the land, appropriate education for teachers in preparation is necessary. Incorporating informal educational community resources in teaching helps to improve teachers' content and pedagogical knowledge, besides improving the STEM knowledge and understanding of the students they teach (Kumar & Hansen, 2018; Brown, 2017; Jung & Tonso, 2006). Completing this task successfully adds to the "successful experience" of the student and "sets the stage for continued success" and raises self-efficacy (Bandura, 1986, noted in Versland, 2016, p. 300). Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the course of action required to produce given attainments. This is in line with construct three of Carlone and Johnson (2007): successful teacher leaders have belief in their own capacity as a teacher leader with strong STEM content knowledge. . . . Mastery of the content taught by teachers and confidence in the pedagogical skills they implement in teaching are critical to sustain teacher leadership qualities. A teacher leader in STEM will not shy away from taking advantage of any reasonable resource within reach to facilitate meaningful learning experiences for his/her students.

Leadership Through Community Engagement

Community engagement activities are an integral part of teaching and learning in STEM disciplines in the College of Education at FAU. Activities have included student volunteers engaging in STEM outreach to local K–12 classrooms and participating in service-learning community activities through informal science education institutions such as science museums, observatories, and planetariums as part of the undergraduate science education course. For example, an opportunity for teacher leadership development for student volunteers through community engagement is available through a local science museum. This is a unique opportunity for improving the pedagogical and science content knowledge of university students in the elementary/middle school science methods course. Preservice teachers need adequate knowledge of and access to reliable community resources in STEM disciplines, which they can tap into in order to develop teaching strategies to connect classroom STEM topics to the world around (Jung & Tonso, 2006). Presenting classroom STEM in the context of applications of STEM in the real world is a pedagogically effective way to augment and enrich students' learning experiences, and it can be achieved by connecting to local institutions such as museums, planetariums, and industries, and by

implementing carefully prepared instructional resources (e.g., multimedia anchors) (Kumar, 2010).

Students who are interested in the community engagement volunteering opportunity express their interest to the course instructor and the designated museum staff. In working with the museum staff the student volunteer sets up an initial appointment to visit the museum and receives a free entry pass and a guided tour of the exhibits at the museum. The tour guide discusses with the student volunteer the STEM-related themes and principles of the exhibits. Depending on their interest and comfort level, each student volunteer selects one exhibit for the community engagement activity. The student volunteer then informs the course instructor and the museum staff of the exhibit chosen and proceeds to develop a detailed lesson plan incorporating pedagogically appropriate hands-on activities in alignment with the Next Generation Sunshine State Standards. Topics related to museum exhibits chosen by student volunteers have included airplane wings (e.g., Bernoulli's Principle), weather, clouds, the water cycle, coral and coral bleaching, sharks, mangroves, the Everglades, etc. Twenty students have volunteered for this project since its inception.

The student volunteer has flexibility in the development of the lesson plan. Once the lesson plan is developed, the course instructor and the museum staff provide feedback. Every effort to improve the quality of the STEM content and pedagogical knowledge is made during this feedback process, with particular attention to misconceptions, correctness of content, cognitive levels of questions, connections to STEM in the real world, and the integration of suitable engaging hands-on activities. After finalizing the lesson plan, the student volunteer works with the museum staff to decide on a mutually convenient time and date to present the lesson in a group setting. Depending on the season, day and time, the group may be K–12 student visitors, tourists, parents, and/or senior citizens. Sometimes selected museum staff members are the audience that provides an opportunity for the student leader to answer questions that help build a deeper knowledge of the subject.

Once the lesson plan is implemented, the student volunteer receives feedback provided by the museum staff. The museum staff shares the feedback with the course instructor along with a summary of key aspects of the lesson presentation. In addition, each participating student volunteer is required to reflect upon their community engagement experience in terms of the following five prompts: (1) Describe any effect of the project on your level of understanding of the Science Concept/Principle you addressed. (2) Describe any effect on your level of confidence in explaining the Science Concept/Principle you addressed. (3) Describe any effect on your ability to relate science to real-world examples. (4) Describe any effect on your ability to teach science. (5) Describe any effect on your decision to utilize community resources such as museums in your future K–12 teaching.

Benefits to the Student Volunteer

At the end of the community engagement activity, the participating student volunteer receives credit in the form of bonus points toward course grade and FAU Academic Service Learning (ASL) credit. Since Fall 2017, students who participate in this community engagement project receive Academic Service Learning credit for approximately 10 hours spent on the project, with the corresponding ASL notation posted to their transcripts. Prior to the implementation of the FAU ASL credits system, participating students received volunteer hours in the FAU-designated Noble Hour. It should be noted that this community engagement by student volunteers supports the "Community Engagement and Economic Development" platform in the "Strategic Plan for the Race to Excellence 2015-2025" of FAU. Since Spring 2019, besides students in "Principles and Methods: K–9 School Science," students in "Science: Elementary and Middle School" and "Science Content: K–6 Teachers" courses are also eligible to participate in this community engagement teacher leadership development project and receive FAU ASL credit. A higher level of confidence, a level of understanding of content and pedagogy, and an ability to incorporate community resources in teaching are all essential to building teacher leadership qualities. As student volunteers build leadership skills through community engagement activities, they help the museum visitors see the exhibits through the eyes of the STEM lessons they present, providing the visitors a different dimension of enrichment and exposure to the exhibits not available elsewhere.

Method

For this preliminary study, data were collected from a reflective survey response completed by students who participated in the museum experience. The reflective survey was developed by Kumar (2017) to allow students to self-reflect on their experiences and provide insights for the research around the impact of the experience on the student's confidence and mastery of the subject. Since the development of the survey 12 students have participated in the project and received the survey, and seven students responded.

Analysis and Results

Each researcher reviewed survey responses individually to identify emerging themes. Researchers then reviewed and analyzed responses together. All responses from the students were coded collectively. Four major themes emerged.

- Self-Confidence Development
- Depth of Understanding of the Topic
- Audience STEM Learning
- Sense of Self-Responsibility

Table 1 summarizes the total responses by themes. In some themes the total number of responses exceeds the number of respondents. An analysis of each theme with specific quotes from respondents follows.

TABLE 1. Summary of Responses by Themes

THEMES	TOTAL RESPONSES
Self-Confidence Development	15
Depth of Understanding of the Topic	14
Audience STEM Learning	7
Sense of Self-Responsibility	4

Self Confidence Development

How did the self-confidence of the individual change during this activity? This theme emerged as the strongest one. Seven of the seven respondents shared 15 responses that support the development of self-confidence.

> *"This experience allows me to be more confident when teaching."*

> *"Presentation and demonstration allowed me to build confidence in explaining [the lesson]."*

Audience STEM Learning

How well did the audience learn the science concept taught by the student? Three of the seven respondents shared seven responses that positively represented this theme.

> *"Because of the level of confidence, I had in my project, this caused audience to gain more knowledge about..."*

Depth of Understanding of the Topic

How did this experience impact the depth of understanding of the selected topic? Six of the seven respondents shared 14 responses that positively represented this theme.

> *"Everything I learned [about my topic] will stick with me forever."*

> *"I have learned a lot about the different components of [the topic]."*

Sense of Self-Responsibility

Did this activity include a sense of responsibility on the part of the student? Two of the seven respondents shared four responses that positively supported this theme.

> *"It is important to me that students understand the effects humans have on the Everglades."*

Discussion and Implications

Teacher leadership development through community engagement is a volunteer project for undergraduate students at FAU. Based on the preliminary data analysis, there are several benefits to students. First, the community engagement activity helps to build a sense of efficacy and self-confidence, which is noted as a valuable part of teacher leadership (Bandura, 1997; Versland, 2016). Furthermore, as noted by Hunzicker (2017), "internal factors such as motivation and confidence are likely to influence the progression from teacher to teacher leader more so than external factors" (p.1). Second, it provides a platform for experiential learning by leveraging community

resources such as planetariums and museums to develop engaging STEM lessons that students identified as a deepening of their subject knowledge as aspiring leaders. Helping teachers develop content knowledge skills in their pre-teaching experiences is important, as these early career teachers may be more likely to advocate for instructional and curricular changes (Raue & Gray, 2015). Students who participate in experiential programs such as this have the opportunity to enter the beginning years of teaching with the ability to lead other teachers as the masters of the curriculum; they have built a sense of self-efficacy through repeated successes, which allows them to perform as confident teacher leaders (Huggins, Lesseig, & Rhodes, 2017; Bandura, 1997; Hunzicker, 2017). Third, it offers considerable pedagogical advantages, providing a unique opportunity to build confidence in teaching STEM lessons to audiences ranging from school children to senior citizens visiting the museum. These benefits are supported by the findings of Hunzicker (2012). Three factors were identified as those that develop teacher leadership: "exposure to research-based practices, increased teacher self-efficacy, and serving beyond the classroom" (p. 267).

Since 2013, 20 students have volunteered in teacher leadership development through community engagement in a museum. However, student self-reflections were not implemented until 2017. Since 2017, 7 out of twelve students have volunteered to submit self-reflections. A longitudinal study of those student volunteers who are now teaching in K–12 classrooms is needed to determine the effect of the community engagement experience on student learning and to understand the nature of teacher leadership development. Augmentation of the 5-item self-reflection questionnaire with additional specific teacher leadership questions is also underway. Based on the outcomes of future research and evaluations, creative ways to improve community engagement opportunities for teachers should be explored in order to contribute toward building teacher leaders who are champions of reforming STEM education in our classrooms.

It should be noted that this is a volunteer activity and that for various reasons, not many students signed up. Most of the students who attend classes on the FAU Broward campus are commuters or are employed full-time or part-time and have family obligations. A few times students who signed up and made the initial museum visit later changed their minds because of conflict of schedule with employment and/or family situations. Some students who struggled with the course have avoided the volunteer activity, while others in similar situations have taken advantage of the opportunity to improve their content and pedagogical knowledge in addition to improving their final grade.

Considering the benefits for student volunteers, opportunities for teacher leadership development through community engagement in partnership with local informal STEM education resources should be further developed. In most cities of the United States, informal science education resources such as museums, discovery centers, and planetariums that are suitable for establishing teacher leadership development opportunities through community engagement in STEM are available for teachers in training. Even in rural areas, building partnerships with farms, forestry businesses, aquaculture, and healthcare for STEM education are possible (Buffington, 2017). Universities and colleges with teacher preparation programs have a responsibility to explore and initiate collaborations with local informal education institutions. By establishing community engagement opportunities aimed at teacher leadership development, they can contribute to efforts to reform school science, technology, engineering, and mathematics education.

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