Examining Undergraduate Students' Perceptions of Service Learning in Upper-Division Mathematics Courses for K-12 Teacher Candidates

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Prospective teachers need hands-on experience in the field before they can independently manage their own classrooms. Although experiential learning is widely acknowledged for its benefits, its implementation in content-focused mathematics courses for prospective K-12 teachers remains limited. To address this gap, mathematics content courses for future teachers should offer experiences that extend beyond traditional classroom settings. One effective approach to achieving this is through incorporating service learning experiences. This paper explores the integration of service learning into three distinct mathematics courses for prospective K-12 teachers, including two upper division mathematics courses, highlighting how this approach was implemented in each course. Results suggest service learning in upper-division mathematics courses benefits prospective teachers by fostering experiential learning, enhancing collaboration, communication, and career skills, as well as deepening engagement with course content and the community.

Keywords: prospective K-12 teachers, service learning, geometry, capstone courses

Introduction

Prospective teachers (PTs) must gain experience in the field before taking charge of their own classrooms (Jackson et al., 2018). Service learning (SL) has been incorporated into teacher education programs around the globe as a teaching strategy to allow PTs to connect theory, practice, and community (Bates & Lin, 2015; Jackson et al., 2018). SL is "a pedagogical and learning strategy used in schools and communities around the world and has produced positive social, emotional, and cognitive growth among students" (Clark, 2017, p. 2). Further, it integrates community service and academic learning, allowing students to contribute to the needs of the community while applying content learned in the classroom (Carrington & Saggers, 2008; Mortari, Silva, & Ubbiali, 2019; Verducci & Pope, 2001). SL methodologies strive to inspire students, offer valuable services to others, establish links between universities or schools and their communities, and offer genuine incentives for introspection (Jackson et al., 2018; Lee & Statham, 2010). Many studies found that participating in SL components of a course enhanced students' understanding of necessary skills and their ability to perform tasks and skills aligned with course learning outcomes (Anderson et al., 2019). Engaging with K-12 students via SL deepens PTs' capacity for empathy, understanding, and encourages them to view students as community members with whom they have a responsibility and desire to connect (Chambers & Lavery, 2012).

Despite the generally favorable reviews of experiential learning, researchers have observed there is a notable scarcity of literature on its application within content-focused mathematics courses designed for K-12 teachers. This gap highlights the need for further research and exploration to better understand how experiential learning can be effectively incorporated into mathematics courses for students majoring in mathematics with a teaching emphasis.

In this study, we explore the following two research questions: (a) What do PTs perceive as the most valuable learning opportunities and skills gained from their involvement in SL activities within content-focused mathematics courses designed for K-12 teachers? (b) How do PTs view the relevance and usefulness of SL experiences in their mathematics courses on their future careers?

Conceptual Framework

Our conceptual framework is based on Carver's (1997) model for experiential education, in which student experience is central. Carver defined this experience through three interconnected facets: agency (A), belonging (B), and competence (C). Agency involves students' self-awareness and their ability to create growth opportunities. Belonging refers to students' integration into a community where they contribute and feel connected. Competence involves acquiring and applying new knowledge and skills. Additionally, the student experience can be seen both as a process and an outcome of the SL experience. Past experiences influence current experiences, making student experience a process and in the end, an output.

The development of ABC occurs as students face challenges, learn from mistakes, and grow as a person. The outcomes include acquiring new skills; becoming more adaptable; and gaining self-respect, peer respect, and a sense of safety. The learning environment supports ABC development through both setting characteristics (resources, behaviors, and shared values) and program characteristics (active learning, authenticity, future connections, and drawing from past experiences). Active learning directly involves students in the learning process while authenticity guarantees that the learning experience is genuine and relevant. Connecting to the future allows students to apply their knowledge to long term goals. These elements contribute to a positive student experience, encouraging PTs to implement similar experiential approaches with their students. We expand on Carver's model by incorporating the future intention of using similar activities or pedagogies as those used during their SL experience (see Figure 1). With positive student experience, we believe that teacher candidates are more likely to view the relevance and usefulness of the SL experiences on their future careers.

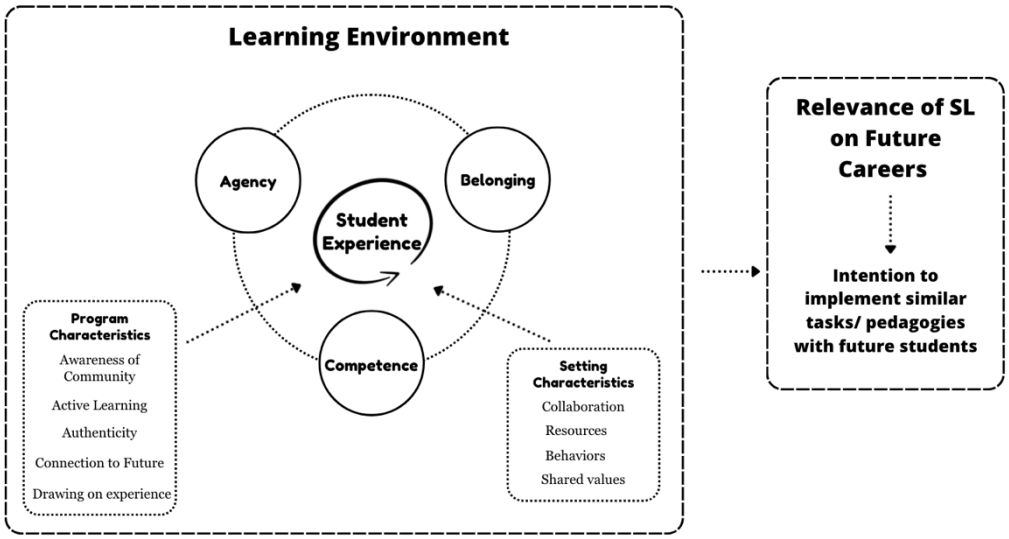

Figure 1. A conceptual framework for experiential learning for PTs (adapted from Carver (1997)).

Methodology

Study Participants

This study was conducted at a public institution on the West Coast of the United States. Participants included 38 students from three SL designated mathematics courses; 36 of whom were planning to become future K–12 teachers. The three courses included in the study were: College Geometry (eight students enrolled), an Elementary Mathematics and Learning Process course (10 students enrolled), and a capstone Mathematics course (20 students enrolled). Both College Geometry and the capstone courses were for math majors in the Teaching Emphasis track.

Course Context

In the College Geometry course, students examined the axioms and theorems of Euclidean geometry and compared various geometric axioms and theorems of Euclidean, non-Euclidean, and finite geometries. In the Elementary Mathematics course, students explored the relationship between mathematics and how it is learned. They expanded their knowledge of K-8 mathematics and explored how to positively impact children's attitudes toward and understanding of the subject. The capstone course provided a culminating experience that bridged the gap between the advanced mathematics studied in college and the mathematics taught in secondary schools. Throughout the course, students explored the nature of mathematics, with the overarching goal of connecting their experiences as learners to effective mathematics teaching.

Service Learning

Each student completed 10 hours of SL in the College Geometry course, five hours in the Elementary Mathematics course, and 26 hours in the capstone course. The SL activities involved (co)facilitating hands-on mathematics sessions with K-12 students, teachers, or seniors, solely based on content learned in the class. In the capstone course, 20 of the 26 SL hours were dedicated to tutoring middle and high school students.

In the College Geometry course, students learned about various finite geometries, such as 3-point geometry, Fano's geometry, and Young's geometry. They applied these concepts to create Spot-it games with three symbols per card, four symbols per card, five symbols per card, etc. Students also explored the application of Young's geometry in the SET card game. They developed presentation materials and hands-on manipulatives and facilitated sessions at a Wellness Program for seniors aged 65 and above, a Senior Living community, and a local Conference for middle school girls.

In the Elementary Mathematics and capstone courses, PTs facilitated various non-curricular, hands-on math activities for high school students from two local schools. They first presented the topics or worked on them with their peers in class, made modifications, and planned their sessions. Some of the topics included applications of number theory, logic, and geometry. Activities included Gerrymandering, Rook's move, etc.

Data Collection

Data was collected through pre- and post-surveys, and beginning- and end-of-semester reflections on students' SL experiences. The pre- and post-surveys included several Likert scale questions, ranging from "strongly agree" (5) to "strongly disagree" (1), along with open-ended questions. The pre-survey questions were adapted from Manolis (2004), while the post-survey

questions were adapted from the University of Georgia - Office of Service-Learning survey (2015). The end-of-semester reflection was adapted from the Campus Compact's "The What? So What?? Now What??? Reflection Model" (Rolfe et al., 2001). "The What?" component describes the event, i.e., facilitating the activities. The "So What" component examines the event's significance in relation to classroom concepts and personal experiences. The "Now What" component reflects on future actions that relate to the broader context of using mathematics in the "real world."

Data Analysis

We used descriptive statistics and an a priori and descriptive coding process (Miles et al., 2014) to interpret the data. The first round of coding involved members of the research team identifying and categorizing codes guided by Carver's conceptual framework on student experience. One PT was counted twice, as they were enrolled in both College Geometry and the Capstone course in successive semesters. In the beginning semester reflection, none of the students had prior experience with SL in a mathematics course before taking the SL courses associated with this study. Four students self-reported having previous SL experience in their education courses, and four other students reported having SL experience through Child and Adolescent Development classes, an art class, or through tutoring students in English.

Research Question (a): What do PTs perceive as the most valuable learning opportunities and skills gained from their involvement in SL activities within content-focused mathematics courses designed for K-12 teachers?

Out of 35 responses in the post-survey, 15 students strongly agreed, and 12 students agreed that the SL component of this course helped them develop their citizenship skills. Eighteen students strongly agreed, and 15 students agreed that the SL component made them more aware of their responsibilities as community members. Seventeen students strongly agreed, and 15 students agreed that the SL component helped them gain more knowledge about the community they worked with and the issues it faces. Twenty-two students strongly agreed, and 10 students agreed that the SL component helped them see how the material covered in the course could be useful in everyday life or in other situations. Nineteen students strongly agreed, and 14 students agreed that the SL component enriched their application of classroom knowledge. Fifteen students strongly agreed, and 18 students agreed that the SL component helped them to develop functional life skills, such as problem-solving, critical thinking, communication, and assertiveness.

From the end-of-semester reflections, student experiences are highlighted through three interconnected facets: agency, belonging, and competence. For agency, a majority of PTs felt a stronger connection to their future roles as teachers or envisioned themselves pursuing teaching in the future after participating in the SL sessions. PTs found it valuable to gain even a small glimpse of what being a mathematics teacher might involve. One PT wrote, "My goal is to become a math teacher and just getting a small insight to what that would be like is nice. It feels good to help people understand even if it is a small game like Spot it." PTs also gained confidence in their ability to teach and support other students within their peer group, with one PT noting that, "a service learning project is not an easy event to execute and through my performance as an individual I was able to not only regain confidence in myself, but also aid others in my group." Most importantly, PTs reflected on issues facing their communities. A PT in the capstone class wrote,

> From my hometown community, there were issues with lack of educational resources and education as a whole (especially mathematics as a subject) was not taken seriously. I

> intend to solve these issues to allow proper education be easily accessible to ensure the success of the students I teach in the future.

For belonging, PTs valued getting to know members of their community and showed a genuine interest in connecting with others on a personal level. One PT enrolled in the College Geometry course wrote, "I feel there was also merit in simply being there and interacting with people, listening to their stories and conversing about a myriad of topics, the simple act of interacting was welcomed." Through community involvement, PTs were also able to engage in generational sharing. During the SL events, PTs were eager to share what they learned in the classroom and became more open to learning from community members. A PT in the College Geometry class working with seniors wrote,

> I want to help others, I want people to learn from me as much as I want to learn from others. I want to be a part of my community, working with others and lending a helping hand in any way I can.

In terms of competence, several PTs felt a sense of accomplishment through teaching. One PT wrote, "Teaching has a way of being rewarding that goes beyond simple thank you's. Seeing those you have mentored grow as learners and then in return want to be a positive influence themselves is amazing." Another PT mentioned the relevance to the application of mathematics, saying, "Something new I learned about my service topic is that it is [not] just about math or geometry. It's about how we can use this math or geometry and apply it to real-world problems to solve them." Other PTs claimed that this experience enhanced their communication skills, with one PT writing that "facilitating the event allowed me to hone my communication and leadership skills, as I guided students through the various activities and encouraged their participation. I also was able to modify the games for students who needed it." Another student reflected on how the SL experience challenged them to make impromptu decisions and produce solutions to challenges they experienced during the SL events, saying,

> There were a lot of English Learning students that came to visit and finding ways to communicate the rules and get them involved was truly a challenge. In my group we did not have a native speaker to assist the students the best we could, but we managed to get by and adapt. I think I personally grew because of this as I was forced to find ways to communicate the material I was teaching to my visitors.

For student experience (as output), it was observed that students found SL to be rewarding and useful for them. Two students enrolled in the College Geometry course stated, "It has really benefited me as a person so doing the service learning with the seniors […] was very rewarding because it's a completely different age group than I'm used to." and "It's very rewarding, seeing people understand things, and knowing that you were a big part of that." Additionally, students asserted that they felt fulfilled (output) by participating in SL. One student wrote, "Learning new things is extremely fulfilling and helpful to people." Furthermore, many PTs expressed that SL allowed them to actively learn the course content. The SL experience aligned well with the content students were learning in their SL mathematics course. One student wrote, "This service-learning experience complimented with what I am learning in the class because the activities always revolve around geometry models and games." The same student then stated that "One new information that I learned about geometry during service-learning was the icosahedron, a platonic solid, because I've never heard of the shape, and I was able to make a model out of paper strips." In addition, students reflected that they experienced personal growth as a learner by interacting with individuals from different age groups and diverse backgrounds. A student in the College Geometry class wrote,

> I grew as a learner as I was able to interact with people who were out of my age range and people who came from different backgrounds and different world[s]. Meeting people who are younger than me […] gave me a brand-new perspective on how they act and view education.

While another geometry student shared, "My motivation has definitely changed from one of completing these projects for credit to completing them to better the community I am now part of." Students were also given the chance to reflect on their past experiences as students and how they can make an impact. One student wrote in their reflection,

> It is important to me that those teaching have a passion towards teaching and care about their students. I've had teachers in the past who just show up and don't care about what their students are learning. This made learning in the classroom miserable. I want students to feel heard and understood. I want them to care about what they are learning so that they can grow up and pass it on. I hope to be a passionate teacher who cares about her children.

Research Question (b): How do PTs view the relevance and usefulness of SL experiences in their mathematics courses on their future careers?

Many PTs shared that they plan to adopt some of the practices they learned through SL in their future careers as teachers. Among the courses from which we collected data, 28 out of 38 participants expressed that their experience with SL has provided them with insights into how they want to teach in the future. The students developed clear and concrete ideas about how they would apply the tools they learned through SL, with one student reflecting, "In the future, I want to use what I learned from these outreach activities in my teaching. I will be adding fun, hands-on games and puzzles to my lessons to get students more involved and help them engage in math."

Another student shared that their experience with SL has better prepared them to obtain their teaching credential, saying,

> This experience taught me the value of collaboration and the importance of working together towards a common goal. As I prepare to start my credential program at [University] and begin my placement at [High School], I am excited to apply the insights and skills I gained from this event. I am eager to create lesson plans that are engaging, culturally responsive, and collaborative. I want to ensure that my students see the relevance of math in their daily lives and feel confident in their ability to succeed.

Through SL, the undergraduate students could see themselves as future and current educators, gaining valuable tools and experience that will help them succeed in the future by making mathematics engaging and relevant to their future students. One student reflected,

> Participating in this event was a significant learning experience for me as a teacher. It taught me the importance of making math engaging and relevant to students' lives. Through hands-on activities and interactive games, I witnessed firsthand how students' enthusiasm for math grew when they saw its real-world applications. This helped me grow in my ability to create inclusive and interactive learning environments. I learned to tailor activities to students' individual needs and interests, ensuring that every participant felt valued and motivated to learn.

Some students demonstrated an eagerness to share mathematics with their future students in a way that combats negative stereotypes and seeks to avoid issues like math anxiety or other negative experiences with mathematics, with one student sharing that, "By attending this event, I learned much about how I can diverge from traditional mathematics education and teach it in a

more exciting and grounded way, which I hope will help absolve mathematics of its negative connotation." It is known that teachers pass math anxiety to students, so having teachers be more cognizant of this and how they can tailor their classroom to their teaching styles will benefit their future students greatly.

Additionally, of the remaining 10 of 38 students who did not clearly indicate an intention to use what they learned through SL in their future classrooms, seven of these students expressed that SL confirmed their desire to teach in the future. Therefore, 35 of the 38 study participants reported that SL gave them confirmation that they want to teach mathematics in the future and gave many of them ideas about how they will be able to engage their future students in mathematics.

Conclusion and Discussion

Written reflections from PTs offered valuable insights into their perspectives on their SL experiences in the (upper-division) mathematics courses. Our results provide support for incorporating SL into upper-division mathematics courses, offering significant benefits for students planning to become teachers, whether at the elementary, middle, or high school level. Through SL, students can engage in experiential learning within their upper division mathematics courses and develop essential work skills, including collaboration, communication, and practical career competencies. Students developed a stronger connection to their future roles as teachers or envisioned themselves pursuing teaching in the future. They strengthened their collaboration and interaction with others in the community. Many students expressed that SL allowed them to actively engage with the course content and complemented what they were learning in class.

Well-designed SL experiences enhance classroom learning and help students not only grasp the content but also develop career-ready skills. This is especially important for undergraduates in upper-division mathematics courses who are preparing to become K-12 teachers. There is no need for PTs to wait until the credential program or student teaching, where the focus is primarily on curricular instruction, to gain teaching experience. SL can demonstrate how and why upper-division mathematics can be meaningfully used in lesson planning for middle and secondary students. Further research is needed to explore the development of upper-division mathematics SL courses that can offer valuable experiences for PTs.

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