7. *Academy for Teacher Excellence: Promoting STEM Education and STEM Careers among Latinos through Service Learning*

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Latino Underrepresentation in STEM

Increasing student enrollment in Science, Technology, Engineering and Mathematics (STEM) careers is considered one of the top priorities in education given the current shortage of STEM professionals, the expected growth in STEM occupations, and the relevance of STEM careers to maintain the US economically competitive (Museus, Palmer, Davis & Maramba, 2011; Taningco, Mathew, & Pachon, 2008). This priority is true for all students in the P-20 system, especially Latinos who are the fastest growing underrepresented population. The US Census Bureau predicts that the Latino population will double by 2050 (U.S. Census Bureau, 2014). Given the projected demographics and the shortage of STEM professionals, increasing the number of an underrepresented group in STEM who will constitute one third of the US population becomes a need. Which leads to the question, how do educators, policy makers, and other stakeholders across the US encourage Latinos to consider STEM careers? Different approaches are implemented to strengthen the STEM pipeline for Latinos, including targeted PK-12 STEM learning opportunities, access to more rigorous courses and dual enrollment (Contreras, 2011; Malcom, 2010). The Academy for Teacher Excellence (ATE) in the College of Education and Human Development (COEHD) at the University of Texas at San Antonio (UTSA) has conducted extensive work to strengthen the STEM pipeline for Latinos, for instance, providing SL opportunities for undergraduate students. In this chapter, we first present an overview of the different SL efforts conducted by the ATE to strengthen the STEM pathways for Latinos; then we present the analysis and results of the impact of SL on academic and informal learning experience of two cohorts of Engineering undergraduates who conducted SL in Robotics clubs.

Pathways to Increase Latinos Participation in STEM

The ATE's major focus is to create pathways to increase Latinos participation in STEM careers, specifically in STEM education. To achieve this goal, ATE has established strengths-based collaboration efforts with colleges across UTSA, in addition to public school districts, community colleges, and community organizations through informal learning opportunities for young learners—protégés. ATE aims to create a research-based model for enhancing and increasing protégés STEM awareness, knowledge, and aspirations by engaging teacher candidates and other undergraduate majors as mentors, promoters, and ambassadors in after-school informal learning experiences; which include: La *Clase Mágica (Magical Class-Bicultural-Bilingual Technology based after-school program) (Flores, Vásquez, & Clark, 2014), Nepohualtzitzin*-Ethnomatematics (Prieto, Claeys, & Lara Gonzalez, 2015) and Robotics clubs (Schuetze, Claeys, Flores, & Sczeck, 2014). In general, the informal learning clubs, provide opportunities to teacher candidates—*aspirantes*, and other UTSA undergraduates from across departments in various colleges to engage in field experiences and/or SL opportunities for mentoring and promoting STEM education and STEM-related careers among. Important to note is that during the 2015–2016 academic year, 66% of the 710 undergraduate students participating in one of the three SL opportunities described were Latino.

ATE's primary collaborators in the creation and implementation of informal learning clubs are high need schools with large numbers of Latinos and English learners. Other ATE partner community organizations with a shared mission to promote a college going culture and facilitate access to college among Latinos and other underrepresented youth in our community include: the Alamo STEM Workforce Consortium, BiblioTech, Cáfe College, *College en la Comunidad*, Hispanic Network of Texas—Latinas in Progress Programs, Latinas SciGirls, the Martinez Women's Center, and San Antonio College Access Network. Over the years, ATE has partnered with these and other organizations to collaborate and leverage resources to reach out to young Latino learners and their families through information sessions, university sponsored events, informal learning experiences, and parent-family summits.

Service Learning and Field Experience as Pathways to STEM Education

In creating and strengthening pathways for STEM Education, ATE collaborates with the Department of Bilingual-Bicultural Studies (BBL) and the Department of Mechanical Engineering to engage bilingual *aspirantes* and other teacher candidates in field experience, and undergraduate students in service learning. Service learning (SL) is an approach utilized to engage *aspirantes* and other undergraduate majors in the three informal learning clubs to mentor protégés and to promote a college going culture in underserved communities. ATE creates innovative transdisciplinary SL opportunities where noneducation majors work with *aspirantes* to become mentors to protégés. Participating mentors get hands-on experiences working with protégés in elementary and middle schools that are highly populated by Latino and English learners. As a result, undergraduates' community SL experiences are connected to the local needs, which often strengthen the STEM knowledge and skills of future educators, in addition to promoting STEM education and STEM-related fields in schools located in underserved communities. With the many academic, financial, and personal demands that college students often face, specifically Latinos, ATE provides the following support services as part of the SL experience: textbook lending, college and career guidance, and psychosocial emotional support. The research-based informal learning experiences designed by ATE (Claeys, Lares, & Flores, 2016) allows *mentors* to serve the community, especially Latinos learners, at the same time that they are provided with guidance to enhance their education and career journeys.

In addition to students volunteering to participate in SL, ATE collaborates with the College of Engineering to integrate SL as an option in one course. Robotics SL is implemented after-school in a semi-structured informal learning environment, which provides opportunities for reflection for the participating Engineering mentors. The First Lego League (FIRST) drives the structure and rigor of the Robotics club since participants spend most of the time learning, preparing, researching, and strategizing for the annual challenge at the FIRST Competition. Schuetze *et al.* (2014) found that there is a better understanding in STEM, in addition to the reciprocal learning benefit for all undergraduates involved and protégés when they work in preparation for the FIRST Competition. Participation in the robotics club not only provides affirmation toward STEM education and career goals, but also fosters aspirational and self-efficacy on everyone engaged (2014). Bhounsule, Chaney, Claeys, and Manteufel (2017) also found academic benefits among mechanical engineering undergraduates who engaged in a SL experience. They indicated that benefits included a letter grade difference, improved communication, presentation skills, and a sense of satisfaction to be able to give back to the community, in addition to getting young learners interested in engineering. These findings are consistent with the results of the meta-analysis in SL conducted by Conway, Amel, and Gerwien (2009), in which SL experiences were found to have a moderate impact on students' outcomes. We believe that SL opportunities address the national need to increase the ethnic and gender representation of professionals in STEM when *aspirantes* and other undergraduates serve as mentors to protégés in underserved communities.

The field experiences for *aspirantes* are part of: BBL 4063-Bilingual Approaches to Content-Based Learning and BBL 3403-Cultural and Linguistic Equity for Schooling in which *aspirantes* mentor elementary and middle level protégés *in La Clase Mágica* and/or the Nepohualtzitzin-Ethnomathematics informal learning clubs. Over the years, these type of field experiences have offered *aspirantes* and protégés opportunities to learn in a playful informal manner, not only culture, language, content, and multiliteracy skills, but also the ancient and modern technological tools such as the nepohualtzitzin, computers, and mobile devices. Also, the engagement of *aspirantes* in these field experiences have served to strengthen, not only the STEM pathways and a college going culture, but the long-term partnerships between UTSA and public schools in our community.

Service Learning: Examining Student Learning

The SL experience developed by ATE is based on the core elements of SL that have been identified in the literature and Engeström's expansive learning framework (Engeström, 2009). The term "service-learning" has been used in different research studies with different meanings. According to Furco (2003), SL has been defined as a program, pedagogy, experience, and a philosophy. The diversity of the terms has its origin on the implementation approaches and conceptualization of SL, in addition to the fact that SL happens in specific settings with different foci. Nevertheless, Howard (2003) identifies *community service* as the element that distinguishes SL from other types of experiential learning. Considering community as a key element, ATE embraces SL as "a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities" (National Service-Learning Clearing House, 2011).

Research demonstrates that SL does enrich the learning experience of students, promotes civic responsibility; and that reflection is needed to enhance SL experiences and community service (Astin, Vogelgesang, Ikeda, & Yee, 2000; Conway *et al.*, 2009). Undergraduates who participate in the SL experience immerse themselves in the informal learning clubs at a public school. Each club is representative of the community and the school culture in terms of the structure set by the trained volunteer sponsors who lead the sessions, including the enhanced learning opportunities that learners acquire and transfer to the classroom, among others. Each session is different from the previous as protégés prepare for the annual First Challenge, putting together new strategies to plan and prepare for the competition. The authors consider that the informal learning opportunities fostered through the Robotics clubs are constantly changing, thus consistent with Engeström expansive theory of expansive learning, which is learning acquired in organizations that are not stable (1987, 2009). The theory of expansive learning (Engeström, 2009) "focuses on learning processes in which the very subject of learning is transformed from isolated individuals to collectives and networks" (p. 5). Thus, all participants interact with a community around a common challenge to be solved, to create a new notion of the interactions. The theory draws from the work of Vygotsky and Leont'ev among others whose concept of the zone of proximal development, and object-oriented theory respectively serve as foundations for expansive learning. As a result, Robotic clubs provide participants the space in which learning occurs as a community of learners interacting to solve problems using different tools and instruments leading to expansive learning and the construction of a new collective and network.

Methodology

Participants

ATE promotes SL and recruits undergraduate participants across UTSA Colleges through classroom presentations, information sessions, a promotional video, and email communication with faculty. In this study, we examine the academic and career impact of the SL program on two student cohorts who served as mentors in the Robotics clubs. The first cohort includes students from various colleges who voluntarily signed up to participate in a two-semester SL experience. The second cohort is a group of Mechanical engineering majors who participated in a one-semester SL experience as part of an elective class. Mentors who signed up to do SL in the Robotics club during the 2015–2016 academic year worked with students in grades 2–8 in high need schools located across San Antonio, TX. Each school counts with volunteers in charge of sponsoring, planning, and organizing the Robotics informal learning club to include protégés from different grade levels to work collaboratively in small groups with the mentors.

Cohort 1: Two-semesters of SL. The first cohort considered for the analysis included 41 mentors recruited from the College of Education, College of Science, and College of Engineering. Participants ethnicity included 65% Latino, 19% Caucasian, 10% African-American, and 6% other; and gender 46% females and 54% males. The SL commitment required the completion of 10 hours per semester at one of the 15 high need public elementary and middle schools located across five independent school districts. The average student demographics for the school districts was 74% Latino and over 40% English learners.

Cohort 2: One-semester of SL. The second cohort considered for this analysis included 33 students from a Mechanical Engineering class who opted to conduct SL (10 weekly sessions of 60–90 minutes) to receive 25% of their final grade. Mentors were learning robotics using LEGO Mind storms with their protégés and in their own university Robotics class. The cohort was 39% Latino, 36% Caucasian, 12% Asian-Pacific Islander and 10% African-American; 12% female and 88% male. Undergraduate students in this Cohort served as mentors to protégés in 10 high need public elementary schools located across four independent school districts.

Research Design

We used a mixed method approach to examine students' perceptions and different experiences during their participation in the SL. A survey (Crano & Brewer, 2002), and a phenomenological approach (Marshall & Rossman, 2014) were implemented to identify the impact of the robotics SL on students self-perceptions of (a) the benefits of the comprehensive technological, counseling and mentoring support provided by ATE on their academic success, (b) the extent to which the program promoted development of skills needed for college success (e.g., teaching and leadership skills), and (c) the success of the SL program in fostering awareness of the need of STEM learning opportunities for underrepresented students (see Table 7.1). Given the focus of the study on the holistic learning experience and impact of the SL on all students who participated in the program, the cross-sectional survey was implemented online at the end of the SL experience to both cohorts.

One of the challenges of SL research is the lack of instruments that can apply to diverse approaches of SL implementation. Thus, ATE researchers designed a 24-item survey to be implemented after students complete the SL experience. The survey addresses the three aspects listed in the previous paragraph, collects students' background information (e.g., gender, ethnicity, teaching experience), and includes a set of open-ended questions to allow undergraduate mentors to reflect on their motivation to volunteer for the SL experience and their expectations. The first set of survey questions included are intended for students to reflect on the impact that support services students can access as part of the SL program, for instance: book and technology lending, counseling services, mentoring, workshop sessions and guidance to navigate the educational system; including awareness of and preparation for graduation requirements. These questions also aim to elicit students' knowledge of how the provided services support their academic success and persistence in college. The second set of questions addresses the SL objective of promoting undergraduate students' development of academic content and skills relevant to their major, including self-perceptions of the STEM knowledge and skills developed. The open-ended questions at the end of the survey address the initial motivation and expectations of students. According to expansive learning, the learner develops new knowledge and applies it in practice. Thus, the open-ended questions would constitute a window to examine how participating in the SL experience helped students develop a new knowledge of what it means to be a mentor and what it means to do Engineering in the context of problem solving with young Latino learners in underrepresented public schools.

For this study, we used a representative sample (n=15) of both cohorts (46% White, 29% Hispanic). The selection of this sample was based on the completeness of the surveys submitted. Given that the survey is answered online, the researchers are not able to identify the reasons why students partially completed or did not complete the survey.

To support students' reflective participation in the program, and further our understanding of the student learning that happens in the informal learning club setting and experiences as Robotics club mentors, Cohort 2 responded to a longitudinal set of open-ended questions. The set of 9 reflection questions were administered throughout the semester.

Table 7.1. Research design for the robotics service learning 2015–2016 cohorts

Cohort Number	Type of Service-Learning Experience	Data Collection Methods
Cohort 1 (n=41)	Service—learning experience (2 semesters—20 hours)	- Survey answered at the end of SL
Cohort 2 (n=33)	Service learning for credit (10 weekly sessions of 60–90 minutes)	- Survey answered at the end of SL - Structured reflections (Set of 2–3 questions answered monthly during SL experience)

Source: Authors

Data from the survey was analyzed descriptively to examine the frequency of responses, which revealed: (1) the extent to which the comprehensive set of services provided by ATE (e.g., book lending, coaching, mentoring, etc.) as part of the SL experience have an impact in students' academic lives, (2) the various dimensions of students' transformations, for instance, whether students became advocates or might become future advocates of STEM careers, changes in their conceptions about what it means to be a mentor, and (3) their initial perceptions and motivation to volunteer for SL in the Robotics club. Given that the set of questions related to initial perceptions and motivations were open-ended, responses were transcribed and coded for emergent themes (Miles, Huberman, & Saldana, 2013). Data from structured reflections was transcribed and coded for themes that reflected their construction of their roles as mentors in the context of problem solving with young Latino learners in underrepresented public schools.

Results and Discussion

Survey Results

Self-Perceptions of the Benefits of the Program. The comprehensive set of services SL mentors have access to when volunteering were found to be an important academic support for 20%, who reported that they could not have been able to complete their college degree without the services provided. From this group of students, 80% identified the experience as an opportunity to learn about their community and give back. In addition, almost 50% of this group indicated that the project staff provided personal and academic support when needed. The survey indicates that the comprehensive set of services provided by ATE (textbook lending, career guidance and psychosocial emotional support) to undergraduate students involved in the SL experience constituted a personal and academic support system that is key to achieve completion of their college degrees and to overcome challenges inherent to being a student. Given that one of the main motivations of the students to serve as mentors to young learners is the desire to be an inspiration and a role model for them, having a support system behind them can potentially foster their sense of community.

Development of Knowledge and Skills. We consider students expressed rationales to serve as mentors in the Robotics club relevant because they indicate undergraduate students' confidence about how to teach and what it means to be a mentor in SL. Nevertheless, these two conceptions changed as mentors engaged with their protégés, as shown by the finer analysis of Cohort II structured reflections. Students' rationale to sign up to serve as mentors in the Robotics' club were analyzed for emergent themes to identify what motivates students to engage in the SL experience. Four categories emerged from the analysis. The first category, *support students to go into STEM careers*, includes responses addressing the desire to provide support to underrepresented students and promote careers related to Robotics. The second category, *be an inspiration to young learners*, represents students' interest in becoming an inspiration for all learners. The interest in inspiriting is rooted in undergraduates' previous experiences with adult mentors, or previous experiences serving as mentors in ATE's SL program. Another group of students expressed that SL was a good opportunity to work with young learners in informal settings. Finally, a group of students were motivated to be mentors in the Robotics club to learn about robotics. Some of the students who volunteered for the SL were from the COEHD, and were not likely to be familiar with Robotics. College of Engineering mentors showed confidence in their content knowledge and their ability to teach protégés. However, as mentors engaged in the Robotics clubs with their protégés, they identified various aspects of teaching and skill development that required changing to successfully interact with protégés. This is shown in the survey results indicating that 66% of the students expressed that they had opportunities to develop skills that are relevant to their career, including teaching and leadership. In addition to developing skills, students also reported an increased interest in STEM careers.

Awareness of the Need of STEM for Underrepresented Students. Overall, results of the survey for both Cohorts indicate that SL has positive effects on more than 60% of the mentors as they reported developing awareness of the need to advocate for quality STEM education for Latinos, low income, and other underrepresented students. These outcomes are similar to the ones that have been reported in the literature as discussed by Celio, Durlak, and Dymnicki (2011). The fact that students reported increased awareness of the need of STEM learning opportunities for Latinos and underrepresented students, learning of knowledge and skills, and the comprehensive set of services provided by ATE were considered fundamental for their academic success, indicating that ATE's SL program generated positive outcomes in at least 60% of the students who responded the survey. This is consistent with the positive academic outcome reported by Bhounsule *et al.* (2017) for Cohort II students. The structured reflections of Cohort 2 provided a more detailed insight into mentors learning as they engaged with their protégés.

Structured Reflections

Development of Knowledge and Skills. Two of the five categories that emerged from the analysis of Cohort II structured reflections are similar to the ones expressed by both cohorts in the Survey: the desire to be an inspiration to young learners and learn about Robotics. The third category represents the mentors' desire to support protégés of Robotics knowledge. Mentors responses classified under this theme reflect their self-confidence in their engineering and technology knowledge, how they can use this resource to support the development of protégés' knowledge, and get them excited about robotics and technology. For instance, one of the mentors expressed: "I had never before taught kids about this kind of concepts. It taught me how to express my ideas to kids and teach them." Another mentor elaborates: "I feel like I have the opportunity to show the students how fun the field of engineering is…." A group of mentors selected the SL option because they already enjoyed teaching children. Finally, learning about student thinking emerged as the fifth category. Opposite to the desire of teaching and sharing their knowledge with students, mentors whose response is categorized under this theme expressed their interest in deepening their knowledge about how students solve Robotics problems. Responses to the survey and the responses to the structured reflections are consistent, and show that these cohorts of Engineering students were excited for the opportunity to share their knowledge and get students excited about their field of knowledge. As a result, mentors were serving as promoters of engineering careers and role models to protégés.

Overall, mentors showed confidence in their ability to teach students Robotics, or be an inspiration to students so they could go into STEM careers. However, initial assumptions of their knowledge about how to teach Robotics were challenged and modified as they engaged with protégés. Engaging in problem solving in an informal and expansive learning setting supported the transformation of mentors' self-perceptions, awareness of need for more Latinos in STEM, and Robotics knowledge. In the context of the informal learning Robotics club and in their roles as mentors, undergraduate students identified the need to further develop their Robotics and Engineering knowledge to be able to communicate core ideas to their protégés. Recognizing the need to deepen the knowledge and adapt it to serve the students is illustrated in the following reflection: "I think the most challenging aspect of being a mentor would be to convey what I know in ways the kids will understand." Even more, mentors modified their thinking to communicate ideas to students in the context of the problem. Thus, mentors are supporting the process of solving problems that might be also new for some of them. The knowledge mentors developed in this process is related to ways in which their content knowledge must be shaped to facilitate their protégés' problem solving process, and to solve the actual problem. The LEGO League challenge created a common space in which mentors and protégés interacted and co-constructed new knowledge in their respective roles as mentors and protégés. In terms of the expansive learning theory (Engeström & Sannino, 2010), the learning that happened for the mentors was twofold: constructing an identity as mentors, and constructing new meanings for the Robotics knowledge to facilitate the process of problem solving. A key aspect of undergraduate students development of a mentor identity and skills, was being able to develop a relationship with their protégés, for which they needed to develop effective communication skills. This relationship was considered necessary to also engage students in the problem-solving process. In general, mentors engaged in diverse interactions with their protégés, however one theme that was common to most of their reflections was being able to help students work through the challenge, which included providing hints, ideas, building teamwork skills and explaining content relevant to the problem.

Conclusion

The study presented in this chapter offers a finer grain analysis of one of the efforts conducted by the Academy for Teacher Excellence to increase Latinos representation in STEM by engaging Latino young learners—protégés in underrepresented communities and undergraduate mentors in informal learning opportunities. The research-based service-learning in an informal and expansive learning experience successfully supports the promising increase for Latino representation in STEM in different ways. First, by partnering with public schools located in lower income communities with high percentage of young Latino learners, provides awareness and access to STEM education and STEM careers. Second, it enhances the preparation of the Engineering student cohorts considered in this analysis—most of which are Latinos, by providing them with opportunities to deepen the content knowledge acquired in their coursework and expanding their academic and professional knowledge and skills through mentor–protégé interactions. From the expansive learning theory stance, strategizing for the annual competition creates the space in which mentors and protégés interact, leading to a mutual transformation of the community in which mentors and protégés are part of. Through their active engagement in this common space, it is evident that mentors and protégés benefited from the development of communication structures that facilitated the establishment of rapport, new conceptualizations of the Robotics content, and the creation of an identity as SL mentors for undergraduate students and as future STEM professionals for protégés.

Overall, we surmise that SL experience impacts both mentors and protégés by creating a community of learners in which both learn from each other coconstructing knowledge in a creative and innovative way. Solving real-world challenges presented by the First Lego League offers the exploration of scientific topics, thus increasing interest in STEM-related careers. Implications for university scholars and researchers including school administrators, educators and community stakeholders include collective networks of university-school-community partnerships to engage in research-practice partnerships to further explore the impact of service learning in underrepresented communities largely populated by young Latino learners in an effort to promote STEM education and STEM careers.

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