Schuetze, Andrew; Claeys, Lorena; Flores, Belinda Bustos; Sezech, Shannon

La Clase Mágica as a community based expansive learning approach to STEM education

International journal for research on extended education : IJREE 2 (2014) 2, S. 27-45

Quellenangabe/ Reference:
Schuetze, Andrew; Claeys, Lorena; Flores, Belinda Bustos; Sezech, Shannon: La Clase Mágica as a community based expansive learning approach to STEM education - In: International journal for research on extended education : IJREE 2 (2014) 2, S. 27-45 - URN: urn:nbn:de:0111-pedocs-229849 - DOI: 10.25656/01:22984

https://nbn-resolving.org/urn:nbn:de:0111-pedocs-229849
https://doi.org/10.25656/01:22984

in Kooperation mit / in cooperation with:

https://www.budrich.de

2 | 2014

Volume 2

IJREE

International Journal for Research on Extended Education

ISSN 2196-3673

Barbara Budrich Publishers

International Journal for Research on
Extended Education, Volume 2/2014

Content

DEVELOPMENTS in the Field of Extended Education

REVIEWS SECTION

AUTHOR INFORMATION

La Clase Mágica as a Community Based Expansive Learning Approach to STEM Education

Andrew Schuetze, Lorena Claeys, Belinda Bustos Flores & Shannon Sezech

Abstract: As an alternative to experimental design, using a social design experiment methodology, we analyzed the Academy for Teacher Excellence's *La Clase Mágica's* (LCM) Robotics Clubs, a university-school collaborative partnership. Given the scarcity of minority representation in the STEM fields (science, technology, engineering, and mathematics), we established robotics clubs to provide young learners, ages 5–14, with STEM opportunities to engage in playful informal learning that promotes creativity, mathematical, and scientific skills along with other forms of literacy. In this manuscript, we describe the learning process that occurs within the robotics clubs established at seven schools who serve large numbers of underserved-underrepresented populations. Multiple data sources include meeting notes, interviews, field notes, and focus groups. The use of multiple data sources, peer-review, and triangulation of the data assisted in establishing trustworthiness. We found that this community based expansive learning approach contributes to the mutual learning benefits of the different participants, learners (protégés) and undergraduate students (mentors).

Keywords: Communities of Practice, Robotics, Latinos, Informal Learning, STEM

1 Introduction

In order to advance our society, we concur that there is a pressing need for individuals to pursue Science, Technology, Engineering, and Mathematics (STEM) careers. The National Academies Press urges the importance of increasing the science and engineering talent to address the present economic challenges (Sciences, Engineering, & Medicine 2011). This is a major concern to the leadership of the U.S., especially when the ethnic minority population, now the largest segment of the society, is underrepresented or not pursuing a STEM field (Dowd/Malcom/Bensimon 2009; Sciences, Engineering, & Medicine 2011). Kao (2007) suggests that not educating a large segment of the population is what he calls the "wicked problem of education" (p. 101). Numerous obstacles denying equity in educational opportunities keep the ethnic minority population from getting a quality education (Valenzuela 1999; National Science Board 2010). To increase ethnic minority participation in the STEM areas requires early exposure and engagement (National Research Council 1996, p. 22; Lee/Luykx 2007). Moreover, researchers speak to the value of inclusive settings, which includes children with varying abilities and language levels, for promoting young children's STEM development (Moomaw/Davis 2010). To alleviate the STEM crisis while providing opportunities for underrepresented populations, several researchers recommend the implementation of educational robotics programs and provide strategies to augment the experience (Cannon et al. 2007; Ludi 2012; Rosen/Stillwell/Usselman 2012). According to Eguchi (2012), "educational robotics is the term widely used to describe the use of robotics as a learning tool" (p. 3). For example, LEGO robotics, because of its interdisciplinary, collaborative, and authentic learning opportunities, can be a conduit to STEM education (Gura 2011). Further, Melchior, Cohen, Cutter, and Leavitt's (2005) longitudinal study indicates that learners engaged in robotics clubs and competitions had an increased awareness of STEM fields and college opportunities. Yet, despite these efforts and similar activities, enrollment and completion rates in the STEM areas continue to be dismal (Snyder/Dillow/Hoffman 2009). In the case of Latinos and other minority students in low-income communities, participation in robotics clubs is limited due to access, high student mobility/transfer rates, and transportation (Yuen/Ek/Schuetze 2013; Yuen/Ek/Rodriguez 2013). In order to address these challenges and to increase ethnic minority students' awareness and interests in STEM careers, we considered Vasquez' (2003) *La Clase Mágica* (LCM) as a promising approach. LCM, which was developed and situated in Latino low-income communities in the larger San Diego area of California, has also provided the theoretical and practical foundations for UC Links, a statewide after-school network funded by the University of California System, and for a larger international network that now reaches across the United States and internationally (Vásquez 2003; Underwood/Parker 2011). Gutiérrez (2014) credits Vásquez (2003) for "an enduring model whose sensitivity to local culture and historical legacies make it portable, permeable, and dynamic and substantially easier to situate and instantiate across a range of communities and contexts" (p. ii).

Given the scarcity of minority representation in the STEM fields, we established *La Clase Mágica* (LCM) Robotics Clubs to provide bilingual and culturally diverse learners (protégés) with playful informal learning opportunities that promote creativity, mathematical, and scientific skills along with other forms of literacy. One of the premises of LCM is to have peer collaborations and horizontal communication. Nevertheless, it is also important to have a knowledgeable other within the community of practice that guides the learner in their acquisition of knowledge. Thus, similar to Bers and Portsmore's (2005) partnership model for integrating LEGO robotics, in LCM Robotics Clubs, teacher candidates and undergraduate engineering majors serve as mentors. As Yuen, Ek, and Schuetze (2013) describe:

> Following the success of the original LCM and the one running at our university, we have based the design of our robotics club on a similar model that emphasizes: 1) awareness of children's language and culture, 2) the use of manipulatives and technology to enhance scientific and mathematical knowledge, 3) and mentoring (p. 2).

Hence, through the LCM's Robotics Clubs, young Latino bilingual and African American learners (protégés) experience early exposure and engagement with the STEM areas. Additionally, LCM Robotics Clubs provide teacher candidates' opportunities to acquire or deepen their cultural, pedagogical, and STEM knowledge for becoming culturally efficacious teachers who can *engage in transformative practices* (Flores/Clark/Claeys/Villarreal 2007; Yuen/Ek/Rodriguez 2013). To date, we have not found research that explores the benefits to undergraduate students who serve as mentors in robotics clubs.

While there has been some anecdotal evidence reported on the educational and affective benefits of educational robotics for upper elementary, secondary, and college students (Barker/Nugent/Grandgenett/Adamchuk 2012; Melchior et al. 2005; Nourbakhsh/Crowley/Wilkinson/Hamner 2005; Nourbakhsh/DiSalvo/Hammer/Lauwers/Bernstein 2007), there is a paucity of research analyzing the learning opportunities and outcomes for elementary and middle school students (Baker et al. 2012; Schuetze, in preparation). The research focus appears to be on the evaluation of various educational robotics programs (Barker et al. 2012; Gómez/Bernstein/Zywica/Hammer 2012). Despite the research findings, over the last 20 years, educational robotics have been incorporated into the formal and informal K-16[1] curriculum (Klassner/Anderson 2003; Li/Chang/Chen 2009). Moreover, Schuetze (in preparation) suggests that the focus of educational robotics has been teacher-centered, rather than learner-centered. He recommends that research efforts are needed to better understand the rich learning process that occurs as learners engage in building and programing robots.

2 Methodology

In this study, we use Gutiérrez' and Vossoughi's (2010) recommended social design experiment methodology as an alternative to experimental design.

> Social design experiments – cultural historical formations designed to promote transformative learning for adults and children – are organized around expansive notions of learning and mediated praxis and provide new tools and practices for envisioning new pedagogical arrangements, especially for students from nondominant communities (p. 100).

Multiple data sources include meeting notes, interviews, field notes, and focus groups. The use of multiple data sources, member checking, and triangulation of the data assisted in establishing trustworthiness (Patton, 2002).

Research Questions

How do Robotics Clubs as a community of practice assist in expanding participants' knowledge?

How do Robotics Clubs mutually benefit all participants?

1 K-16 refers to formal and informal education systems for students in grades Kindergarden through 12 and post-secondary education. The purpose of K-16 is to align academic content and instructional practices, including the creation of policy and graduation requirements.

Sites and participants

This study was conducted at multiple sites: five elementary schools (grades 3–5) and two middle schools (grades 6–8) in a city situated in the southwestern part of the United States. All seven schools are located in low-income communities and the majority of children qualifies for free or reduced lunch.

Afterschool Club Sites. All of the schools participating identified at least half of their total student population as Hispanic. These participating schools also have a teacher population of at least fifty-percent or more self-identifying as Hispanic**.** The majority of the teacher club sponsors are Hispanic (5), followed by White (3), and African American (1). Table 1 provides an overview of participants' demographics.

Table 1. Participating Sites Demographics

LCM Robotics Site	Student Hispanic Population	Economically Dis-advantaged	Teacher Hispanic Population
Elementary 1	98.40%	93.20%	60.60%
Elementary 2	99.30%	95.70%	88.60%
Elementary 3	78.10%	82.70%	65.50%
Elementary 4	95.70%	94.50%	79.00%
Elementary 5	98.10%	91.90%	62.20%
Middle School 1	92.90%	90.50%	2.2.7 58.00%
Middle School 2	90.00%	77.20%	57.20%

Source: Texas Education Agency AEIS Reports 2011–2012

UTSA Mentors. Undergraduate students (mentors) from across colleges at the University of Texas at San Antonio (UTSA) volunteered to mentor the elementary and middle school learners (protégés) participating in the afterschool robotics clubs. Table 2 shows that a total of thirty-seven undergraduate students participated as mentors for two consecutive academic semesters from the following majors: Computer Science (CS), Interdisciplinary Studies with Teaching Concentration in Math and Science grades 4–8 (IDS), Kinesiology (Kines), Mathematics (Math), Mechanical Engineering (ME), and Science.

Training. Prior to the implementation of the clubs to ensure program integrity, teacher sponsors and university mentors received basic LEGO Robotics training. Each undergraduate mentor was required to complete six contact hours, while the teacher club sponsors received three days of training. Training included building a robot, basic programming, and practice completing basic challenges similar to what elementary and middle school protégés would complete throughout the club meetings and while at competition.

Frequency of Meetings. Each afterschool club met one day a week for one to two hours, excluding the weeks when there was a major holiday break or state mandated testing. From the beginning of September to the middle of May, an estimated total of 21 meetings were held, with one site meeting 39 times.

Table 2. Mentor Descriptive Data

Academic Major		CS	IDS	Kines	ME	Math	Sciences	Total
Gender								
	Male	1	2	1	13	4	3	24
	Female	0	6	0	3	3	1	13
Ethnicity								
	White	0	0	0	5	1	1	6
	Hispanic	1	8	1	8	4	3	25
	African American	0	0	0	1	1	0	2
	Asian	0	0	0	2	1	1	4
Classification								
	Freshman	0	0	0	5	1	0	6
	Sopho-more	0	0	0	6	1	0	7
	Junior	1	0	1	5	4	2	13
	Senior	0	8	0	0	1	2	11
Total Mentors		1	8	1	16	7	4	37

Source: The Acadamy for Teacher Excellence 2013

Materials. Multiple sets of the LEGO Mindstorms NXT base kit, as inspired by Papert (1980), were selected and provided to each LCM Robotics Club. Each kit contains 431 elements including the programmable NXT brick, three servo motors, and several sensors to include: touch, light, ultrasonic, and sound (The LEGO Group 2013).

Club structure. The FIRST LEGO League (FLL 2013) competition model was used as the structure for guiding club activities because FIRST has demonstrated success in engaging and increasing high school graduation rates and college enrollment for minority students (Afterschool Alliance 2011). FLL engages teams of up to ten students in both a thematic game challenge as well as authentic research on a self-selected problem within the game theme. The LCM Robotics Clubs had an average ratio of 1 mentor per 3 protégés and 1 to 2 club sponsors. During the 2012–2013 FLL season, the theme was 'Senior Solutions.' As a result, the game missions focused on challenges faced by senior citizens: taking medicine, exercising, walking upstairs, and several others (FLL 2013).

Procedures. To identify a research project with the theme of 'Senior Solutions,' the robotics clubs are tasked with interviewing senior citizens in their community. Then, team members engage in a discussion about the variety of challenges identified by the senior citizens to make a decision on the research question that they would address as a team. The teams conduct research and prepare to present their solution to invited community experts, such as health providers. This independent research and presentation provides protégés opportunities to be creative and engage in authentic activities that promote mastery learning (Bandura 1993). In order to score points in the tournament, teams present their research and design, as well as accomplish a variety of missions (program and control of robot) in a friendly competitive format. To emphasize the team concept, an award is given to the team with the highest score on the table missions. Nine additional trophies[2] are awarded based on presentations and interviews of the team conducted by three separate panels of judges in the areas of robot design, research project, and the FLL core values (e.g. gracious professionalism, teamwork, cooperative learning, discovery learning, and friendly competition). Two additional trophies are awarded to championship quality teams. Teams are allowed to compete at one of three local qualifier tournaments and the top third of the ranked championship quality standards teams from each tournament then competes at the local Championship Event.

3 Theoretical Framework

Our theoretical framework is guided by a socioconstructivist transformative lens that intersects the work of Freire (1970) and Vygotsky (1978), among others. We see learning occurring within a community of practice (Lave/Wegner 1991) as an expansive process in which protégés' depth of knowledge is guided through negotiation and deliberation with others (Engeström/Sannino 2010). We also situate our theory of learning as Clark, Flores, and Vásquez (2014) eloquently describe as based on the Mayan's notion of interdependence between humans and nature:

> Using the snail as a symbolic tool of transformation, we conceptualize learning as a spiral process that begins with the individual in harmony with others – expert guides – family, teachers, friends, etc. As learners encounter others along their cyclical path, their sphere of knowledge widens and deepens (p. 215).

Our theoretical lens is also informed by Papert's theory of constructionism (1980). Papert differentiates constructivism from constructionism with the latter focusing on the learner building or constructing models, such as sand castles, block structures, and robots. In these learning rich activities, Papert suggests learners have the opportunity for engagement and creativity, which are aligned with the tenets of *La Clase Mágica* (LCM) that include joint-mediated activities and dialogue within a community of practice (Flores/Vásquez/Clark 2014). Constructionism also requires negotiation and deliberation with peers in the building process of a model that complements Engeström's (2001) expansive theory.

Literature Review

Papert (1980) has been a trendsetter in K-12 educational robotics since his early days at Massachusetts Institute of Technology (MIT) when he piloted Turtle Robots

2 Trophies are awarded for best presentation of research, best research, most innovation solution to the research problem, best computer program, best mechanical design, most innovative solution to the game missions, best demonstration of teamwork, best demonstration of communication, and best demonstration of exhibiting the FLL Core values.

with children. His work led to the development of LEGO RCX Mindstorms along with other educational robotics kits, which allowed the proliferation of educational robotics (ER) to be integrated into classrooms. Consequently, engineering and technology knowledge skills are promoted (Bers/Portsmore 2005; Feng/Hung/Sui 2010; Klassner/Anderson 2003).

These ER kits provide protégés' opportunities to creatively design, program, and control robots. With the onset of educational robotics, in the early 1990's, organizations such as FIRST (2013), BEST (2013), and Botball (2013) were formed with the intent to engage teams (learners, teachers/sponsors, mentors) in meaningful problem-solving competitions that promote interest in STEM careers. To build suspense and continuously motivate the protégés' engagement, an annual theme or challenge is broadcasted nationwide. With anticipation for the annual competition, as a joint activity, teams begin the iterative process of planning, building, and testing innovative designs to address a community challenge, such as meeting the needs of people with physical disabilities. In the FIRST LEGO league competitions, which is the model used in our Robotics Clubs, teams are recognized for a variety of efforts, including team building, innovative design, and presentation of the problem-solving process and solution. Yuen, Ek, and Schuetze (2013) indicate: "This aspect creates authentic learning opportunities as the students select the problems to solve and share their solution with others" (p. 2). In addition to team work, which is an authentic workplace skill, other effects include expanding learners understanding of STEM concepts (Melchior et al. 2005; Nugent/Barker/White/Grandgenett 2011). Driven by the desire to design an operative robot, learners acquire concepts such as ratios and proportional reasoning within a context of informal learning (Petre/Price 2004). For example, as learners design robots' lifts and arm mechanisms, they use ratios and proportional reasoning to determine speed and torque (rotational force).

Rusk, Resnick, Berg, and Pezalla-Granlund (2008) suggest that using an interdisciplinary approach to broaden the robotics clubs experience attracts diverse learners with varying interests and abilities. They provide the following strategies in implementing an interdisciplinary approach: "(1) focusing on themes, not just challenges; (2) combining art and engineering; (3) encouraging storytelling; (4) organizing exhibitions, rather than competitions" (p. 1). For example, in Ribeiro, Costa, and Pereira-Coutinho's (2009) case study, using Grimm fairy tales as their theme, they engaged 4th and 6th grade Portuguese children in a collaborative team process in which tasks were distributed based on individual's strengths and interests to design and develop costumes, props, and robots. As a result, Ribeiro et al. (2009) point out the benefits of integrating ER with dance, dramatic storytelling, and music: "it develops the critical thinking; it develops logical thinking; it increases the interaction and the autonomy in the learning process; and, it raises the interest and motivation for learning" (p. 400). As a means to attract more females into robotics, rather than focusing on competition, Hammer, Lauwers, Bernstein, Nourbakhsh, and DiSalvo (2008) created the Robot Diaries workshops as an interdisciplinary approach for young middle school girls to engage in robotics and technology discovery learning. In comparing the Robot Diaries and Digital Youth Network (DYN), Gómez et al. (2012) observed two types of collaborative models. The DYN focuses on designing robots for social change with the goal of participating in robotics competitions, whereas RD promotes girls participation in the exploration and use of creative technology. Researchers found that both models assisted in building technical knowledge, and provided opportunities for collaboration and leadership for the 9–14 year old participants.

4 Results

We will first provide an overview of three clubs as case studies (Yin 2003), which participated in the local FLL competition. Specifically, we will describe the process undertaken in their research project and robotic solutions. Teams A and B are elementary school clubs, while Team C is a middle school club. This will be followed by a thematic analysis of what occurred within the community of practice.

Research, Process, and Robotics Solutions

During the initial club meeting with the teacher club sponsor, mentors, and protégés, the teams reviewed the FLL project document to begin their brainstorming process. In addition to identifying the theme, this document guides the teams' work, which includes the FLL basic components: choose a community, identify a problem, create an innovative solution, share with others, and present a solution at a tournament. A initial step is to have the team define the community in which they will identify a problem to solve. The sponsor and mentors guide the team with prompting questions: Who should be part of our community? Who should we interview? Who do you know who is a senior citizen? In our teams' cases, they chose to define the community as the school staff and family members.

In the second meeting, based upon protégés expressed interests or observed strengths, the teams were divided into sub groups to accomplish tasks, such as interviewing, online research, and speaking to experts in the community. The sponsor and mentors, in subsequent meetings assisted the sub groups to share their findings with the team and to begin the discussion about potential solutions to the problem. With the facilitation of the club sponsor and mentors, all possible solutions were explored as part of the engineering design cycle. At the team competitions, clubs are evaluated on their research solutions, robotic design, and presentations using the FLL core values: teamwork, effective communication, and engagement of their community in STEM activities.

Team A Research Solutions and Robotic Design. As a result of initial deliberations, Team A interviewed senior citizens with sleep apnea; the seniors talked to the team about the condition and impact on their daily lives. In subsequent meetings, while one sub group designed a novel breathing device, another sub group conducted research on the brain. Team A's final design was a smaller and more comfortable breathing device. At the competition, Team A did not advance from the qualifier level, but learned that they needed to provide evidence and document their project's development as part of their first year learning process. Nevertheless, sponsors reported that the protégés developed a sense of 'team' and self-confidence in guiding each other with various aspects of the competition.

Team B Research Solution and Robotic Design. Team B followed similar research and design processes as Team A. After team deliberations, they decided to create a hand-held device for seniors with Alzheimer's who live alone. This device would serve to remind seniors about their daily routines. After interviewing their grandparents, the team researched Alzheimer's disease and the effects on brain. This teams' novel solution was to modify a voice recorder with user-friendly buttons and attaching a wrist strap. Initially, Team B activities were dominated by males, which diminished the role of females on the team. However, the sponsor observed that the process of question prompting, deliberations, and encouragement from adults allowed females to increase their self-confidence, participation, and leadership role in team activities and discussions.

At the local qualifier event, Team B competed with their robot design to accomplish game challenge tasks associated with the Senior Solutions theme. These challenges were of the typical LEGO robot types of moving or retrieving small objects on the competition board with a time limit of two minutes and thirty seconds per round. In this season, the challenges consisted of mobility issues for seniors, assistive devices, and senior recreation activities. The team utilized their prototypical prompting question strategies and decision matrix to determine which game challenge tasks to undertake. The team had to weigh several factors such as feasibility and points earned verses the time that it takes for the robot to complete the task. Team B competed with their robot in three rounds; and as the sponsor indicated "ended up in the middle of the pack" in terms of highest match score. A key learning outcome was that the team determined that more time and experience building and programming LEGO robots during club meetings would likely result in an improved performance. This strategy resulted in greater success in year two.

Team C Research Solution and Robotic Design. Team C also followed a similar research and design processes as the two prior examples. After team deliberations, they decided to create a mobility device for senior citizens for standing from a seated position. As a result of their research, they designed a device similar to the two-wheeled Segway, by adding a steering wheel for maneuvering. This team interviewed relatives, investigated assisted living centers, and researched types of powered wheelchairs. Based on the overall performance, this team almost qualified for the local championship tournament. Team C reflected on the challenges experienced at the tournament realizing that not all of them had fully engaged in the research and design process, thereby affecting their robot programming and presentation. Consequently, the team rededicated themselves to invest more effort to compete in a subsequent robotics competition. This time, the team tied for first place in an underwater robotics competition. The support structures provided by the sponsors and mentors facilitated the protégés resolve to engage in teamwork and adopt a stronger work ethic.

In sum, these three cases provide a holistic view of clubs as communities of practice in which adults guide and facilitate learning through an inquiry dialogic approach. As a result, protégés acquire STEM knowledge, programming and building skills, and self-efficacy. We also note the importance of peer guidance to achieve these same outcomes. Incorporating team-building activities within the community of practice was instrumental in ensuring that the students built on each other's strengths and worked as a team. In the subsequent section, we engage in a thematic analysis of what occurs within the community of practice.

Thematic Analysis

As evident in these cases, the community of practice is the overarching support and organizational structure. This theme is exemplified by Pedro, a Latino, 5th grader, "We get together as a family, since we're a big group, we get together and help each other out, and well we're just like a family, but we help [build] robots." Lave and Wegner (1991) suggest that learning occurs within a group who share a common interest, actively engage in dialogue, and participate in the co-construction of knowledge. The community of practice also allows participants to appraise other group members in a different light, as Enrique, a 5th grade Latino, reflects:

> I've learned that working with people you don't really talk to a lot, it's really fun because you get to know them better and you know that they're pretty cool and are able to do a lot of stuff you didn't think that they were able to do. It's just fun working with them 'cause they're nice.

Similarly Ms. Sanchez, a teacher club sponsor, acknowledges the potential and strengths learners display as a result of their participation in informal learning:

> As a teacher, it's really great for me to work with these kids after school in sort of a less structured environment, because I've really gotten to see their personalities develop and see them work on things that they don't get to work on during the day umm and I've enjoyed that. I think that having the extracurricular part of my day has actually helped *me* find more joy in my work, because I get to see these kids in such a different context, which has been really cool, and it's also gotten me really excited to see what's going to happen next year.

To gain a greater understanding of the learning that is occurring within the community of practice, we must move from the macro-lens to a micro-lens as contemplated by Engeström (2001):

> For situated learning theory (Lave/Wenger 1991), motivation to learn stems from participation in culturally valued collaborative practices in which something useful is produced. This seems a satisfactory starting point when we look at novices gradually gaining competence in relatively stable practices. However, motivation for risky expansive learning processes associated with major transformations in activity systems is not well explained by mere participation and gradual acquisition of mastery (p. 141–142).

Using a micro-lens, the following themes emerged: aspiration, efficacy, and expansive learning. These micro-themes capture the essence of collaborative community based informal learning.

Aspiration

There are several sources that influence young learners', ages 10–13, career aspirations. These sources and degree (%) of influence include family and close family friends (47%), interest garnered through informal learning (33%), formal school activities (25%), media (18%), and perceived income status (7%) (ASPIRES 2013, p. 7). As we can note, family, acquaintances, and/or informal learning experiences are the major source (80%) of young learners' aspirations. Given the underrepresentation of ethnic minority professionals in the STEM fields, often minority and other low-income learners do not have access to STEM role models within their family, acquaintances, or minority teachers (Amos/Jani 2007). We contend that providing an informal learning opportunity, such as the LCM Robotics Clubs can augment their interest as we have observed in reviewing the transcripts. We noted that there were different types of aspirations: immediate, intermediate, and long term. For some participants, engaging in the robotics club stirred their motivation to remain in school. Jonathan, an African American 8th grader, reveals, "Being in robotics has helped me because I was going to leave the school, but since I'm in it they let me stay." For others, participating in the LCM Robotics Clubs affirms their desires and interests to go to college. Nick, a Latino, Biochemistry Major in his junior year, reports, "Many [participants] shared their interest in going to UTSA after graduation, which also was a victory to me! To have them start thinking about [college] at a young age gives them a goal to complete their high school career successfully." Long-term STEM career aspirations are evident in both elementary and middle school protégés. Darious, a 7th grader, declares, "I want to become an engineer now that I've done this, and seeing what engineers do, and how much fun they have while working." Xochilt, a bilingual Latina 5th grader, also expresses an interest in STEM:

> I want to be a technology teacher. I want to teach kids how to make stuff. How to, not [just] like buy it when it's all done. I want them to figure out the stuff by themselves, like to go into a program and make it yourself and all that. Not to just go, press, install it and that's it.

We also noted that undergraduate mentors were also driven by immediate and long-term aspirations. In the case of some mentors, they aspire to be role models and to be change agents. Jamiah, an African American, Mechanical Engineering sophomore, discloses, "I feel giving back to the community of San Antonio is very important so the kids can learn that they too can overcome obstacles in the robotics program as well as their educational career." While Stephanie, a Latina, Math/Science senior, seeking middle level teacher certification, expresses:

> I joined the robotics mentoring program because I wanted to motivate the students at the elementary level to pursue challenging obstacles. I am joyfully committed to transforming the future of education and helping every student to succeed in the STEM fields.

The mutual reciprocal benefits for the young learners and mentors alike is evident in Pearl's, an Asian female, Mechanical Engineering sophomore, reflection:

> I'm loving this robotics club! It's great being able to work with kids and seeing that this could potentially shape their path for their own future. And it's also shaping mine and making a big impact on my life. As an engineer major, I still am not sure what exactly I want to do with that when it comes to my career, but because of this opportunity, I am really considering in combining engineering and kids somehow. I don't really want to be a teacher per say, but I would love for kids to be involved in my job.

Within the community of learners, schooling and career aspirations emerged and are affirmed, thereby, assisting participants with their STEM professional identity and career development. Whereas aspirations reveal how an individual perceives their future selves and direction, efficacy helps us understand learners' beliefs about their capacity to accomplish tasks and goals.

Efficacy

The LCM Robotics Clubs as a community of practice provides opportunities to support learners' self-efficacy development. Bandura (1993) indicates that there are four sources mediating the development of self-efficacy: mastery, vicarious (learning by observing others), verbal persuasion, and physiological states. In observing the community of practice in action, we noted how participants learn vicariously from each other through observation and demonstration when designing and building the robots. Verbal persuasion was evident when the mentors would encourage the learners to try different solutions or provoke their thinking through questions such as “what else can you try?” “Is there another way to make your robot work?” The robotics club as a community of practice is situated within a non-threatening environment in which participants engage in joint decision-making and problem solving without stress or fear of reprisal. Mario, a Latino Mechanical Engineering sophomore, reveals:

> I think that it made me more comfortable with people that I do not know. Even though I love working with kids, at times I can become shy and kind of back out into my own little world, but being in those environments, you had to loosen up.

Hence, in the community of practice, the physiological state of the learners is supported and learning is accentuated because it occurs within an authentic contextualized setting. An example of mastery learning is evident in Xochilt’s, a bilingual 5th grader, interview:

> It has helped me a lot in my [classes] like in science [and] math ‘cause well in the robotics club it makes you measure and do the volume of things and all that stuff, so in math it helps me do the measurements of the rotations or something like that, and then science it helps me [with] the curve terms [geometry] and all of that, so it actually does help me a lot in math and science to understand it better.

Similarly for Daniela, a math-science major seeking middle level teacher certification indicates, “It was an amazing learning experience for both me and the students. It made me sure about my future profession as a teacher. I feel more comfortable with the kids and it has boosted my teaching confidence.” One of the aims of the Academy for Teacher Excellence is to prepare teacher candidates to be able to work with ethnically and linguistically diverse students to promote candidates attainment of cultural teaching efficacy (Flores/Vásquez/Clark 2014; Yuen/Ek/Rodriguez 2013). In the case of the teacher candidates, the experience not only supports their self- and cultural teaching efficacy, but it allows them to see the capacity of learners. Steven, a math/science major seeking middle level (grades 4–8) teacher certification comments:

> I felt that being a mentor for the robotics club has opened up my eyes to possibilities of success in my students. I am proud to say that I can be part of this journey with them as they continue to challenge their education and face obstacles.

The opportunities to engage in informal learning through the robotics clubs boost the self-efficacy of all participants, with mastery learning experiences being the most powerful and transformative. As a result, the joint authentic and active learning expands the learners’ thinking, confidence, and capacity.

Expansive learning

Engeström and Sannino (2010) indicate that learning occurs as learners construct and implement “radically new, wider, and more complex object and concept for their activity” (p. 2). Robotics clubs, as expansive learning in a community of practice, allow learners to experience problem solving in authentic real-world challenges in designing and constructing robots with others. In the following excerpt, we also note in Emilio's, a 5th grader, reflection that solutions to a problem take time and patience and do not come easily:

> Robotics has helped me because I've learned how to have more patience and put things together and it's been really fun actually too, because all the things we are doing has to do with building and separating [organizing materials]. And on the computer, I like programming a lot and it's taught me how to do that [programing], like we are doing other projects and its taught me how to do it with the computers and other projects.

In learning with others, Emilio's knowledge is expanded while his efficacy as a learner is strengthened. This type of discovery learning is in contrast to the traditional problem solving that occurs in schools, in which there is an emphasis on a linear process in attaining a solution. In traditional learning theories, Engeström (2001) posits: "It is a self-evident presupposition that the knowledge or skill to be acquired is itself stable and reasonably well defined" (p. 137). Mrs. Clark's, a teacher club sponsor, reflection eloquently contrasts the traditional learning theory:

> We're able to work with this community and show them different areas of science and technology in a way that is right in their own classroom, so instead of talking about these case studies of you know in worlds they can't imagine, they see exactly what it feels like to struggle with something and also see how they can use their reasoning skills and their science skills to solve a problem, so I think that at our campus it's been a great *window* to a world that's different…

Expansive learning activities, such as robotics clubs, foster protégés' and mentors' creativity, imagination, recursive discovery process, and natural curiosity – inquiry learning. In addition, robotics clubs cultivates the 21st Century skills of problem solving, communication, collaborations, and teamwork in an afterschool environment (Afterschool Alliance 2011). Mr. Elizondo's reflection supports this notion:

> I have seen how working in extracurricular activities helps them [protégés] develop their communication skills. It helps them develop their leadership skills and it helps them work in teams, which is very important. One of the things I have seen in my kids is they have a lot of exposure in problem-solving and they have been able to work together to solve different problems that they encounter during our meetings whether it is building the robot or making it do the task correctly.

Moreover, it also promotes mathematical and scientific knowledge and thinking as Victoria, a bilingual 5th grader, shares:

> It has helped me because there is a lot of math that we do in robotics like measuring how far the robot needs to go or how much the tires rotate and how fast it should go. There is a lot of adding and subtracting.

Thus, as an example of expansive learning, Victoria's acquisition of mathematical and scientific concepts within the robotics club allows her to incorporate this knowledge within the formal classroom experience. As a teacher, Ms. Castillo has been able to witness the transfer of knowledge from the informal setting to the classroom:

> I know that the kids that we've been able to work with this year have been tremendously impacted. From what I've noticed just seeing that science and math as something outside of a multiple choice question, working all year on the same kinds of problems, and seeing like,

"Oh, I have to find the perimeter. I have to *measure* things that are real." I think that's been a really great impact when it comes to math and science and then when it comes to their communication skills and just their confidence.

5 Discussion

The aspirational value of robotics clubs has been well-documented in the literature (Melchior et al. 2005; Nugent et al. 2011). Our research extends these findings by demonstrating the bidirectional benefits of the LCM Robotics Clubs with aspirational gains for both the protégés and the mentors. In these results, we also observed LCM participants and mentors developing self-efficacy towards STEM learning and career goals. The expansive learning view within the constructionist environment supports this observation, contrasting the assumption that learning is unidirectional. While both groups attained self-efficacy, their gains were unique. In the case of the mentors who had a deeper understanding and knowledge of the STEM concepts, they developed self-efficacy in relationship to career goals and community engagement activities. Specifically, teacher candidates' cultural teaching efficacy is enhanced through these experiences. The club participants, as protégés, experienced opportunities to enhance career aspirations, self-efficacy, and STEM content knowledge. This mutually beneficial learning environment is created within a community of practice approach situated in the broader context of authentic learning challenges. The FLL broad themes with a balanced approach to robot design and the authentic community research challenge, accentuate all participants within the community of practice to over-come obstacles, engage in problem-solving, and learn new STEM concepts and related vocabulary. Mrs. Lozano confirms: "It helps the students see what a college student does and they work together. They have academic-rich conversations, which is very important for our students." Moreover, within the community of practice, the club participants' efficacy is supported in which they feel comfortable and described as a family – a STEM family engaged in a research challenge. Mr. Rincón, a teacher club sponsor, reflects:

> The students have been impacted as a result of participating in the robotics club. They have learned how to work as teams. They have learned how to depend on each other's strengths. Some kids are very good at building the robot; other kids are very good at programming the robot. And working as a team has helped them develop those skills.

Likewise, mentors' sense of efficacy is accentuated when they feel at ease serving as facilitators within the community of practice. Collectively, these experiences promote all participants' achievement at higher levels of performance in all aspects of the tournament experience.

6 Conclusions

In conclusion, the use of robotics clubs within a community of practice supported by the LCM model has aspirational and self-efficacy impacts on all members of the learning environment. Protégés and mentors experience a variety of gains in STEM knowledge and understanding as well as affirmation towards STEM career goals. To scaffold protégés' acquisition of STEM vocabulary, we recommend interactive journaling in which mentors review and respond to journal entries. Mentors would serve in a similar role as *EL Maga* – a magical virtual entity in LCM, which has been very successful across sites (Arreguín-Anderson/Kennedy 2014; Vasquez 2003; Yuen/Ek/Schuetze 2013; Yuen/Ek/Rodriguez 2013). Another recommendation is to collaboratively engage protégés, mentors, teachers/sponsors and university faculty in participatory action research. Moreover, to ensure the LCM Robotics Clubs sustainability, we recommend for teachers/club sponsors and site administrators to engage in seeking external funding from the school districts' educational foundations and other external funding from the private sector. We suggest that these activities would promote expansive and transformative learning that results in the betterment of STEM educational opportunities and access.

Acknowledgements

The authors wish to express their gratitude to the Academy for Teacher Excellence, College of Education and Human Development at The University of Texas at San Antonio and the faculty, staff, teachers, undergraduate Service Learning mentors in the various departments from the Colleges of Education and Human Development, Engineering, and Sciences participating in the Informal Learning Robotics Clubs supported by a Title V for Hispanic Serving Institutions-STEM grant.

Disclaimer: The contents of this article were developed under a grant from the Department of Education. However, those contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government. (Authority: 20 U.S.C. 1221c-3 and 3474).

References

Afterschool Alliance (2011). *STEM learning in afterschool: An analysis of impact and outcomes*. Available Online at: http://www.afterschoolalliance.org/STEM-Afterschool-Outcomes.pdf, [01.10.2013].

Amos, L.B./Jani, N. (2007*). National Science Foundation model institutions for excellence expanding the K-16 pool of potential STEM graduates*. American Institutes for Research. Available Online at: http://www.air.org/files/Expanding_the_Pool_FinalReport.pdf, [22.10.2013].

Arreguín-Anderson, M. G./Kennedy, K. D. (2014). Aspirantes' consejos on El Maga and the role of technology. In: B.B. Flores/O.A. Vásquez/E.R. Clark (Eds.), *Generating Transworld Pedagogy: Reimaging La Clase Mágica* (pp. 117–127). Lanham, MD: Lexington Publishers, Rowman Littlefield Publishing Group.

ASPIRES. (2013, Spring). *Interim Research Summary, ASPIRES Project*. Available Online at: http://www.kcl.ac.uk/sspp/departments/education/research/aspires/ASPIRES-summary-spring-2013.pdf, [10.03.2013].

Bandura, A. (1993). Perceived self-efficacy, cognitive development and functioning *Educational Psychologist*, 28(2), 117–148.

Barker, B. S./Nugent, G./Grandgenett, N./Adamchuk, V. I. (Eds.). (2012). *Robots in K-12 education: A new technology for learning*. Hershey, PA: IGI Global.

Bers, M. U./Portsmore, M. (2005). Teaching partnerships: Early childhood and engineering students teaching math and science through robotics. *Journal of Science Education and Technology*, 14(1), 59–73.

BEST. (2013). *Boosting Engineering, Science, and Technology*. Available Online at: http://www.bestinc.org/b_organizational_goals.php, [04.02.2013]

Botball (2013). *Standards-based educational robotics program*. Available Online at: http://www.botball.org/, [19.06.2013].

Cannon, K./Lapoint, M. A./Bird, N./Panciera, K./Veeraraghavan, H./Papanikolopoulos, N./Gini, A. M. (2007). Using Robots to Raise Interest in Technology Among Underrepresented Groups. Robotics & Automation Magazine, *IEEE,* 14(2), 73–81. DOI: 10.1109/mra.2007.380640

Clark, E. R./Flores, B. B./Vásquez, O. A. (2014) Iluminadas a través de Cosmovisión: A New Age of Enlightenment for Pedagogía Transmundial. In: B.B. Flores/O.A. Vásquez & E.R. Clark (Eds.), *Generating Transworld Pedagogy: Reimagining La Clase Mágica* (pp. 209–220). Lexington Publishers, Rowman Littlefield Publishing Group.

Dowd, A. C./Malcom, L. E./Bensimon, E. M., (2009, December). *Benchmarking the success of Latina and Latino students in STEM to achieve national graduation goals*. Los Angeles: Center for Urban Education, University of Southern California. Available Online at: http://cue.usc.edu/projects/Dec_2009_NSF_Report_Final.pdf, [17.06.2012].

Eguchi, A. (2012). Educational robotics theories and practice: Tips for how to do it right. In: B. Barker/G. Nugent /N. Grandgenett/V.I. Adamchuk (Eds.), *Robots in K-12 education A new technology for learning* (pp. 1–53). Hershey, PA: Information Science Reference. DOI:10.4018/978-1-4666-0182-6.ch00.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14, 133–156. DOI.org/10.1080/13639080020028747.

Engeström, Y./Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), 1–24. DOI: 10.1016.j.edurev.2009.12.002

Feng, E. Z./Hung, C./Sui, C. C. (2010). Student satisfaction and self-efficacy in a cooperative robotics course. *Social Behavior & Personality: An International Journal*, 38(8), 1135-1146.

FIRST. (2013). *Foundation for Inspiration, Recognition of Science and Technology.* Available Online at: http://www.usfirst.org/aboutus/vision, [04.02.2013].

FIRST LEGO League (2013). *Challenge: Overview and history.* Available Online at: http://www.firstlegoleague.org/challenge/thechallenge, [21.10.2013].

Flores, B. B./Clark, E. R./Claeys, L./Villarreal, A. (Fall 2007). Academy for Teacher Excellence: Recruiting, Preparing, and Retaining Latino Teachers though Learning Communities. *Teacher Education Quarterly*, 34(4), 53–69.

Flores, B. B./Vásquez, O. A./Clark, E. R. (2014). *Generating Transworld Pedagogy: Reimagining La Clase Mágica*. Lexington Publishers, Rowman Littlefield Publishing Group.

Freire, P. (1970). *Pedagogy of the oppressed*. New York: Herder and Herder.
Gómez, K./Bernstein, D./Zywica, J./Hamner, E. (2012). Building Technical Knowledge and Engagement in Robotics: An Examination of two Out-of-School Programs. In: B. Barker/ G. Nugent/N. Grandgenett/V. Adamchuk (Eds.), *Robots in K-12 Education: A New Technology for Learning* (pp. 222–244). Hershey, PA: Information Science Reference. DOI:10.4018/978-1-4666-0182-6.ch011.
Gura, M. (2011). *Getting started with LEGO robotics: A guide for K-12 educators*. Washington, D.C.: International Society for Technology in Education.
Gutiérrez, K. D. (2014). Foreword: La Clase Mágica: An enduring prototype for the New Latin@ Diaspora. In: B.B. Flores/O.A. Vásquez/E.R. Clark (Eds.), *Generating Transworld Pedagogy: Reimagining La Clase Mágica* (pp. vii–xii). Lexington Publishers, Rowman Littlefield Publishing Group.
Gutiérrez, K. D./Vossoughi, S. (2010). Lifting off the ground to return anew: Mediated praxis, transformative learning, and social design experiment. *Journal of Teacher Education*, 61(1-2), 100–117. DOI: 10.1177/0022487109347877.
Hamner, E./Lauwers, T./Bernstein, D./Nourbakhsh, I./DiSalvo, C. (2008). *Robot diaries: Broadening participation in the computer science pipeline through social technical exploration*. Paper presented at the Proceedings of the AAAI Spring Symosium on Using AI to Motivate Greater Participation in Computer Science.
Kao, J. (2007). *Innovation nation: Why America is losing its innovative edge, why it matters, and what can we do to get it back*. New York, NY: Freepress.
KIPR. (2013). *Botbal.* Available Online at: http://www.botball.org/about, [04.02.2013].
Klassner, F./Anderson, S. D. (2003). LEGO MindStorms: Not just for K-12 anymore. Robotics & Automation Magazine, *IEEE*, 10(2), 12–18.
Lave, J./Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press, Cambridge.
Lee, O./Luykx, A. (2007). Science education and student diversity: Race/ethnicity, language, culture, and socioeconomic status. In: S. K. Abell/N. G. Lederman (Eds.), *Handbook of research in science education* (2nd ed.) (pp. 171–197). Mahwah, NJ: Lawrence Erlbaum Associates.
Li, L. Y., Chang, C. W./Chen, G. D. (2009). Researches on using robots in education. In: M. Chang/R. Kuo/ K. Kinshuk/G.-D. Chen/M. Hirose (Eds.), *Learning by playing. Game-based education system design and development* (pp. 479–482). Berlin, Germany: Springer.
Ludi, S. (2012) Educational robotics and broadening participation in STEM for underrepresented student groups. In: B. Barker/ G. Nugent/ N. Grandgenett/V. Adamchuk (Eds.), *Robots in K-12 Education: A New Technology for Learning* (pp. 343–361). Hershey, PA: Information Science Reference. DOI:10.4018/978-1-4666-0182-6.ch017
Melchior, A./Cohen, F./Cutter, T./Leavitt, T. (2005). *More than robots: An evaluation of the FIRST robotics competition participant and institutional impacts*. Waltham: Brandeis University.
Moomaw, S./Davis, J. A. (2010). STEM comes to Preschool. *Young Children*, 26(5), 12–14, 16–18.
National Research Council. (1996). *National Science Education Standards*. Washington, D. C.: National Academy Press. Available Online at: http://www.nap.edu/openbook.php?record_id=4962, [20.05.2011].

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital*. National Science Foundation, Arlington, VA. Report NSB 10-33. Available Online at: http://www.nsf.gov/nsb/publications/2010/nsb1033.pdf, [19.09.2013].

Nourbakhsh, I. R./Crowley, K./Bhave, A./Hamner, E./Hsiu, T./Perez-Bergquist, A./Wilkinson, K. (2005). The robotic autonomy mobile robotics course: Robot design, curriculum design and educational assessment. *Autonomous Robots, 18*(1), 103–127. DOI: 10.1023/B:AURO.0000047303.20624.02.

Nourbakhsh, I./Hamner, E./Lauwers, T./Bernstein, D./Disalvo, C. (2006, 6–8 Sept. 2006). *A roadmap for technology literacy and a vehicle for getting there: Educational robotics and the TeRK Project.* Paper Presented at the 15th IEEE International Symposium on Robot and Human Interaction Communication – RO-MAN.

Nourbakhsh, I./Hamner, E./Lauwers, T./DiSalvo, C./Bernstein, D. (2007, March). TeRK: A flexible tool for science and technology education. Paper presented at the Proceedings of AAAI Spring Symposium on Robots and Robot Venues: Resources for AI Education, Stanford, CA.

Nourbakhsh, I. R./DiSalvo, C. F./Hamner, E./Lauwers, T./Bernstein, D. (2007). Robot diaries: An interdisciplinary collaboration to design and evaluate educational robotics. In: *AAAI Spring Symposium: Multidisciplinary Collaboration for Socially Assistive Robotics* (pp. 56–58). Available Online at: http://www.aaai.org/Papers/Symposia/Spring/2007/SS-07-07/SS07-07-013.pdf, [19.09.2013].

Nugent, G./Barker, B./White, A./Grandgenett, N. (2011, June). *The impact of robotics competitions on youth STEM learning, attitudes and 21st century workplace skills.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011, Lisbon, Portugal.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York, NY: Basic Books.

Papert, S./Harel, I. (1991). {Situating Constructionism}. In: S. Papert/I. Harel (Eds.), *Constructionism*. Ablex Publishing Corporation.

Patton, M. Q. (2002). *Qualitative research & evaluation methods*. (3rd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Petre, M./Price, B. (2004). Using robotics to motivate 'back door' learning. *Education and Information Technologies*, 9(2), 147–158. doi: 10.1023/b:eait.0000027927.78380.60.

Ribeiro, C. R./Costa, M. F. M./Pereira-Coutinho, C. (2009, October*). Robotics in child storytelling*. Paper presented at the International Conference on Hands-on Science, Ahmedabad, India.

Rosen, J./Stillwell, F./Usselman, M. (2012). Promoting diversity and public school success in robotics competitions. In: B. S. Barker/ G. Nugent/ N. Grandgenett/V. I. Adamchuk (Eds.), *Robots in K-12 education: A new technology for learning* (pp. 326–342). Hershey, PA: Information Science Reference. DOI:10.4018/978-1-4666-0182-6.ch06.

Rusk, N./Resnick, M./Berg, R./Pezalla-Granlund, M. (2008). New pathways into robotics: Strategies for broadening participation. *Journal of Science Education and Technology*, 17(1), 59–69. doi: 10.1007/s10956-007-9082-2.

Sciences/Engineering/Medicine. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Washington, D.C.: The National Academies Press. Available Online at: http://grants.nih.gov/training/minority_participation.pdf, [01.10.2012].

Schuetze, A. (in preparation). *Mechatronic Storytelling*. Unpublished Dissertation, University of Texas at San Antonio.

Snyder, T. D., Dillow, S.A., and Hoffman, C.M. (2009). *Digest of Education Statistics 2008* (NCES 2009-020). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Stubbs, K./Casper, J./Yanco, H. A. (2012). Designing evaluations for K-12 robotics educational programs. In: B. S. Barker/G. Nugent/N. Grandgenett/V. I. Adamchuk (Eds.), *Robots in K-12 education: A new technology for learning* (pp. 31–53). Hershey, PA: Information Science Reference. DOI:10.4018/978-1-4666-0182-6.ch.002.

Texas Education Agency. (2012). *2011–12 Academic Excellence Indicator System*. Available Online at: http://ritter.tea.state.tx.us/perfreport/aeis/, [01.11.2013].

The LEGO Group. (2013). *LEGO Mindstorm NXT base set*. Available Online at: http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com, [24.20.2013].

Underwood, C./Parker, L. (2011). The tools at hand: Agency, industry and technological innovation in a distributed learning community. In: M. Bowdon/R. Carpenter (Eds.), *Higher education, emerging technologies, and community partnerships: Concepts, models, and applications* (pp. 300–313). Hershey, PA: IGI Global.

Valenzuela, A. (1999). *Subtractive schooling*: U.W.-Mexican youth and the politics of caring. Albany, NY: State University of New York Press.

Vásquez, O. A. (2003). La Clase Mágica: *Imagining optimal possibilities in a bilingual community of learners*. Mahwah, N.J.: Lawrence Erlbaum Associates, Publishers.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Yin, R. K. (2003). *Case study methodology: Design and methodology*. Thousand Oaks, CA: Sage.

Yuen, T. T./Ek, L. D./Schuetze, A. (2013 August). Increasing participation of underrepresented minorities in STEM through robotics clubs. In *Teching, Assessment and Learning for Engineering (TALE), 2013 IEEE International Conference on* (pp. 24–28).

Yuen,T. T./Ek, L. D./Rodriguez, M. E. (2013). *Increasing participation from underrepresented minorities in STEM through robotics clubs.* Proceedings of the International Conference on Teaching, Assessment and Learning for Engineering, 24–28.