



Engagement in Practice: Tensions and Progressions of a Robotics Service-learning Program

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Since fall 2011, the University of Maryland (UMD) Science Technology and Society College Park Scholars program (STS) has offered a robotics service-learning program. Typical of service-learning, the program has both a classroom component on the UMD campus and a service component at nearby K-12 schools and community centers (Mitchell, 2008). UMD undergraduates register for a course, offered in the fall and spring semester, where teams of 3-5 UMD students use Lego NXT and EV3 robotics kits for instruction¹, lead during or after school robotics clubs at nearby K-12 schools or community centers. From 2011 – 2018, the program evolved through four overlapping phases: the program pilot → program expansion → continued growth and curriculum redesign → program stability. After providing context, this paper details key tensions, progressions and lessons learned during each phase of the robotics program.

STS and robotics service-learning: making the match

The STS is a two-year living learning program sponsored by the A. James Clarke School of Engineering and supported by College Park Scholars (CPS) and the Office of Undergraduate Studies (STS, 2018). The primary goal of STS is to “give students analytical skills that help connect science and technology to broader social needs” (UMD STS, 2018) and typically serves engineering and computer science majors. The robotics service-learning course is an elective within the STS curriculum.

The service-learning program started as a way to match STS student interests in STEM and robotics with demand from community organizations seeking STEM related programming and outreach. Seeing an appropriate match, STS piloted a 1-credit robotics based service-learning practicum with a nearby public high school (HS) in Fall 2011. Since, the program has evolved from a one-credit course with a single school site and six participating UMD students to a 3-credit course with 10 K-12 service sites and more than 50 undergraduates per semester (Table 1).

Table 1.
Summary of K-12 partners and UMD student participants over time

Year	Fall '11	Spring '12	Fall '12	Spring '13	Fall '13	Spring '14	Fall '14	Spring '15	Fall '15	Spring '16	Fall '16	Spring '17	Fall '17	Spring '18
# schools	1	1	2	3	5	5	7	8	8	9	9	10	9	9
# students	5	8	10	11	22	18	26	37	30	35	36	46	35	45

Note: An undergraduate TA accompanies each K-12 site.

Phase 1: The Pilot (Fall 2011 – Spring 2012)

The pilot year included thirteen UMD students, one UMD undergraduate teaching assistant (TA) and the author² (Aruch), at a nearby high school (HS). The group traveled to the HS every Thursday for 75 minutes to support an after-school robotics club. The onset of a new program brought a number of challenges and tensions including UMD student recruitment, K-12 school partnership, curriculum and materials.

¹ The course also supports high school vex and FRC robotics teams

² During the pilot, Aruch was a graduate assistant for the STS program.

UMD Student recruitment

To attract participants for the 2011 – 2012 pilot, students were recruited from STS and other CPS programs. Five students signed up in the fall and eight students in the spring version of the pilot course.

K-12 School recruitment and partnership

Initially, developing effective communication lines with the HS was difficult. While the HS was confirmed and a HS teacher was in place at the service-site, it took some time to find the right administrative contact points at the school due to a leadership transition. In addition, although the school and teacher had agreed to host the program, no discussion had taken place about the day or time of the program meetings. Eventually, the cooperating teacher agreed that UMD students would work with the HS students on Thursdays at the end of the school day from 3:30 – 4:45. The teacher also assumed the responsibility for recruiting HS students and acquiring appropriate robotics materials.

Curriculum and materials

Going into the first semester of the pilot, it was anticipated that our partner school would obtain robotics materials and have a curriculum in place. These materials were expected to be part of an existing or emerging robotics program at the school. To this end, the STS team expected to enter an environment that they could apply their technical knowledge to assist with the robotics curriculum and share university experiences. Unfortunately, the school had not purchased materials for the robotics club nor was there a plan for activities. Throughout the academic year, the teacher referred to the arrival of materials that never showed up. There were several reasons for this including a leadership transition at the school, lags in procurement and challenges in communication. To overcome this hurdle, we ‘dusted off’ some older robotics materials from the HS closet to work with throughout the academic year.

For the UMD curriculum, the program model was tested. At the service site, 1-2 UMD students worked with a team of 3-4 HS students to design, build and program a robot. The course met once per week on Thursdays from 3:30 – 4:45 at the end of the school day. Following the service visit, UMD students completed an online discussion log of their activities indicating what they did, what went well, what did not go well and what they hoped to do for the following week.

Lessons learned

Following the first-year pilot, we learned several lessons. First, undergraduate students, despite the challenges really enjoyed the experience of leaving campus to work with students in the community. Second, it was essential to have the UMD instructor and community partner involved in the planning process early to discuss and manage expectations for program design. Third, recruiting undergraduate students early would help us determine how many K-12 students or schools we could serve. Finally, we needed to address this issue of quality materials at the service-site. We incorporated these lessons into our planning as we moved into second year and expanded our offerings.

Phase 2: Program expansion (Fall 2012 – Fall 2014)

In the program expansion phase, STS added partners and developed more collaborative communication with K-12 schools and cooperating teachers. In addition, we began acquiring our own robotics materials. While some tensions were addressed during the expansion, others emerged including lingering UMD student recruitment issues, K-12

student and partner school recruitment, curriculum and materials, transportation, fundraising, outreach and finding partners and allies.

UMD student recruitment

After the first year, STS increased the number of participating UMD students through a “road show” that included events and classroom visits that advertised the course as an attractive program option within the STS curriculum, other CPS programs and departments around the UMD campus including the Engineering school and the College of Education. We recruited enough students to add additional K-12 partners each semester in this phase (Table 1).

K-12 school recruitment and partnership

With confirmed UMD student participants, STS recruited additional K-12 partners. Using google maps in summer 2012, principals and science teachers of public elementary, middle and high schools within 6 miles of the UMD campus were emailed and invited to participate in an after-school robotics program. We received responses from one elementary, one middle and one high school. In addition, word traveled around campus about the program. An undergraduate engineering student had a similar program at a nearby elementary school. When he graduated from UMD, STS inherited his school and Lego robotics materials. By Fall 2014, the program had five participating schools.

Curriculum and materials

In summer 2012, STS investigated various robotics platforms including Arduino and Vex, but decided on Lego robotics due to the familiarity, simplicity and durability of the materials. Using grant and co-curricular CPS funds, 8 Lego NXT robotics kits were purchased. UMD students brought Lego robots each Thursday to their service sites from 3:30 – 4:45 to design, build and program their robot and continue to log their activities online. The course continued as a 1-credit, one day per week class.

Transportation

Additional K-12 schools and UMD students meant additional transportation requirements. Initially, STS hired teaching assistants with their own vehicles to transport the UMD group to service sites. However, after receiving a grant for program expansion, TAs drove rented vehicles from UMD’s motor transportation services to bring UMD students to and from service sites.

Grants and fundraising

Program expansion meant additional costs for TAs, materials and transportation. STS strategically sought co-curricular grants from donors on and off campus. In addition to CPS funds, we applied for and received a Moving Maryland Forward Grant from UMD’s Office of Diversity and Inclusion (UMD, 2018). The grant permitted the financing of additional kits, salaries for TAs and university vehicle rentals.

Partnerships, allies and outreach

STS began to seek out and partner with other on and off campus organizations with similar missions of promoting robotics and STEM education. On campus, we began working more closely with the Maryland Robotics Center, the Center for Minorities in Science and Engineering and the College of Education. Off campus, we began to work with organizations including FIRST robotics, Lego Education and Let’s Go Boys and Girls. We also began participating in on and off campus STEM education events offering Lego robotics demonstrations.

Lessons learned

Phase two built upon the successful components of the pilot. Clearly, UMD students and K-12 schools exhibited interest in the program. Program expansion demonstrated the importance of building relationships and networks with partner schools and allied groups. We learned about the financial and administrative costs of running and growing a service-learning program. In addition, Lego robotics clubs were established as the core of our program offering. Program expansion was so successful that the GA (Aruch) transitioned to a full-time faculty position in Fall 2013, allowing for the commitment of time and resources necessary to consider curriculum redesign.

Phase 3: Continued growth and curriculum redesign (Fall 2014 – Spring 2017)

In 2014, to attract additional students and provide a more rigorous academic experience, STS shifted the course from one credit to three-credits. The 3-credit course, *Contemporary Issues in STEM education*, meets Tuesday and Thursdays for 75 minutes. On Tuesday, the course meets in a UMD classroom and discusses pedagogy, service-learning, and concepts from science and technology studies. On Thursdays, students visit service sites. During the curriculum redesign, the course continued expanding to include more partner schools, undergraduate students and teaching assistants (Table 1). The redesign and growth of the program created additional challenges and opportunities in UMD student recruitment, K-12 school recruitment, curriculum and materials, fundraising, and networking.

Student recruitment

Moving to 3-credits attracted UMD students from across campus into the course. The new course syllabus met two of UMD's general education requirements and aligned more closely with student program plans. Rather than using the "road show" model for recruitment, the program leveraged its growing campus network.

K-12 School recruitment

Instead of active recruitment, the program added K-12 school partners through colleagues and allies within our network through outreach events and in one instance, when a cooperating teacher moved to and started the program at a new elementary school. By the spring of 2017, the program was partnered with 10 service sites.

Curriculum and materials

The biggest shift in the program occurred within the UMD curriculum. Moving from one to three credits afforded UMD students and instructors the opportunity for more engaged, critical perspectives on STEM education, pedagogy and service-learning, including "critical issues" such as gender, race, socioeconomics, stereotype threat and higher education. The course evolved based on UMD student and cooperating teacher feedback to incorporate more intentional lesson planning toward grand robotics challenges. In addition, course assignments focus on leveraging site visits as a vehicle to investigate course topics. The UMD classroom component includes invited speakers from our on and off campus network who can offer different perspectives on the theoretical and practical aspects of the program.

Grants and fundraising

Fundraising is an ongoing tension within the program, as growth requires more resources. STS has drawn from grants and funding streams both on and off campus to offset some of these costs. On campus, the UMD general education designation 'I-series' course brings resources for teaching assistants (UMD, 2018). Off campus, community

focused grants from neighborhood foundations like the College Park Community Foundation has helped purchase additional Lego resources. (CPCF, 2018).

Partnerships, allies and outreach

As the program has grown, so has participation in on and off campus STEM education programs such as the USA Science and Engineering Festival in Washington DC. UMD student course participants are often recruited by our network of STEM education non-profits and community organizations for summer jobs and internship. Similarly, K-12 students and teachers sometimes participate in network STEM events.

Lessons learned

During this phase, the value and importance of our STEM education network became evident for recruiting and retaining K-12 students and partner schools, fundraising, and increasing the profile of our program. As a result, concerns about program stability diminished and we focused more closely on program growth and curriculum refinement in the program stability phase.

Phase Four: Program Stability (Fall 2016 -)

The program no longer actively seeks growth through the addition of UMD students or K-12 partner schools. Instead, the goal is to “build out” the K-12 and UMD curriculum and “build upon” relationships with our partners. During this phase, the program addresses new tensions including curriculum refinement, maintaining and engaging our school partners, and understanding our program through research.

Maintaining and engaging existing K-12 partners.

Program implementation brings to light several tensions with our K-12 service sites. For example, there are consistent questions around the number and length of visits to school sites. While most of our visits occur after school, we have one partner that incorporates our program into the school day. We are also concerned with the number of K-12 students we serve, teacher engagement, school accountability, and how to maximize program benefits with our partners. In addition, we struggle with the extent to which we should expect or promote engagement and accountability with our cooperating teachers and service sites. At this point, teacher participation is variable, ranging from highly engaged to rarely engaged with UMD or K-12 students during robotics activities. Similarly, K-12 student attendance is frequently cited as an issue for UMD undergraduate course participants. Over time, there have been issues retaining school sites from year to year. Schools have dropped (and sometimes returned) for issues like teacher and administrative turnover and competing STEM programs. One program goal is developing sustainable partnerships with our K-12 sites to mitigate these obstacles.

Curriculum and materials.

UMD student feedback and instructor observations also illuminate tensions in the curriculum. For UMD students, there is a tension between the theoretical and critical components of the course (e.g., service learning; issues of race, gender and class in STEM) and the practical knowledge needed to teach robotics in the K-12 classroom. UMD students describe this disconnect by stating they “don’t have time” to consider course content while dealing with the immediate needs of their K-12 student groups.

There is also tension regarding an open versus rigid K-12 robotics curriculum. The program currently employs an open-ended curriculum where UMD student groups pace their own K-12 groups toward a decided upon program goal. Each service site runs its own program. Program growth has meant UMD students with varying technical and

teaching skills. UMD students and instructors question how much of this curriculum should be scripted for students looking for support versus how much of the robotics curriculum can be left open ended for others with more expertise.

Deciding which program learning outcomes to assess another tension. To what extent are we process or outcome oriented as we engage with the robotics materials? Clearly, it is important that our K-12 robotics clubs have a positive experience with the UMD students and materials, but are we more interested in the week to week interactions than the actual robotics or programming learning outcomes? Likewise, where should we focus our assessment, on our K-12 student learning outcomes or our university student learning outcomes? If the focus of the program is engaging the community in STEM education, we should consider the K-12 student or service site outcomes. At the same time, UMD has institutional goals related to our undergraduate students.

Ongoing grants, fundraising and outreach

The initial period of fundraising and grants have kept the program sustainable. To maintain and continue program growth, STS consistently explores other resource streams, which requires continual, intentional networking and partnership development.

Research

Research is an important area of need for the program. Unfortunately, the haphazard and administration heavy nature of the inception and development of the program left little room for intentional research. There are several potential lines of research related to engineering education, community engagement, STEM education, and K-12 learning outcomes. Now that the program is stable, resources and expertise can be committed to investigating important questions related to program outcomes.

Lessons learned

The stability phase demonstrates that despite advances to solidify the program as part of the STS and UMD community, there are several future considerations. With the sustainability of the program no longer in doubt, staff and students now concern themselves with how content can and should be delivered, building meaningful partnerships, financial sustainability, and developing meaningful research projects to help us learn how to improve and make contributions to other, similar programs.

Conclusion

The UMD STS robotics service-learning program is an important part of the on and off-campus UMD STEM education community. Since 2011, the program, has offered robotics education programming for K-12 public schools and community centers. Over time, the program has gone through four overlapping phases. Through each phase, program administrators identified several tensions related to the recruitment of UMD students and K-12 service sites, curriculum and materials, fundraising, outreach, and research. While much effort has gone into developing, administering and expanding the program infrastructure, little systematic data collection or program evaluation of outcomes for either the UMD undergraduate or K-12 students. Moving forward, the STS program aims to address tensions in program growth, curriculum development, community partnerships and program evaluation through a focused research program.

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