Enhancing outreach through the University of Ottawa Maker Mobile

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Abstract
The Maker Mobile program is a new model for outreach at the faculty of engineering at the university of Ottawa that allows for yearlong delivery of high quality technology workshops to the community at large. Through the transportation of rapid prototyping technologies in a 12-foot orange cube truck, the Maker Mobile delivered more than 719 workshops and reached more than 14000 youth in the past year. In particular this program is helping teachers incorporate engineering into their classrooms through hands on design activities. This fosters interest for engineering while helping recruitment efforts. The Maker Mobile is also helping the faculty develop relationships with high schools, teachers and school boards for the development of new spin off outreach initiatives. The Maker mobile builds on a solid foundation for outreach at the faculty of engineering. Three important factors have contributed to the development of a strong foundation for our outreach program. These factors include developing processes that ensure sustainability and scalability, a strong association to the institution, which creates demand for programs and an internal support structure that ensures programs have the necessary resources to scale.

Keywords: *high schools, workshops, making, design, outreach, youth, recruitment, makerspace,*

Introduction
The Faculty of Engineering at the University of Ottawa has a long history of effective outreach programming aimed at raising the awareness and interest of youth for engineering and computer science. Originally bootstrapped through grassroots student-led initiatives, outreach programming has gradually become an integral part of the Faculty's core activities. The goal of this paper is to explore the recently established Maker Mobile program as well as the context that has allowed it to flourish and grow.

Outreach has rapidly become a key activity for engineering schools in Canada and abroad as illustrated by the following examples. Genalo et al. (2000) reported an increase of 10% in first-year enrolment following the introduction of a comprehensive outreach program at Iowa State University. The Rochester Institute of Technology has developed an '*Introduction to Engineering Technology*' program that female engineering students deliver to Grade 4 – 7 schoolgirls (Dell et al., 2011). Nadelson and Callahan (2011) quantified the effectiveness of engineering outreach activities in changing the perception of the discipline by the young girls and boys participants.

Building a solid foundation
In 1991, two students from the Faculty decided to pilot a 2-week summer camp that would help foster interest for engineering and science by young kids. This wasn't unique to the University of Ottawa since

many other student groups across the country were piloting similar projects at their own host institutions. This was all done in the wake of the 1989 École Polytechnique Massacre in a push to foster interest in engineering and science to all youth demographics in an inclusive fashion.

This grassroots movement from students pushing for the development of outreach programs (summer camps and school workshops) had many benefits that helped them flourish and grow. The Faculty's Adventures in Engineering and Science summer program, provided dynamic hands on curriculum and created highly immersive programs that were very attractive propositions for parents and teachers who were looking for accessible STEM content for youth. Student-run programs were also financially lean, relying heavily on extremely passionate teams who were focused on making an impact. But the benefits of the student-run model also brought forth a series of challenges that pledged the long term sustainability of outreach at universities. Student were not long term staff, which meant organisational knowledge was often lost, best practices were often redeveloped every year, and planning was limited to short term goals.

Fortunately, the Faculty of engineering at the University of Ottawa was able to overcome many of these early challenges to develop a foundation that has helped diversify outreach efforts that support institutional mandates and goals. Three main factors can be attributed to the success of outreach in recent years. (see figure 1)

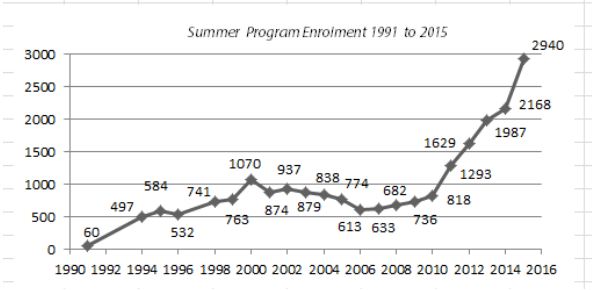

Figure 1. Summer Program Enrolment 1991-2015

Sustainability & Scalability

Without full-time staff, proper infrastructure and processes, outreach programs would have not been able scale and maintain sustainability. This is why the implementation of full-time staff for outreach was an absolute necessity. The full-time model allowed for long term planning, yearlong fundraising capability, development of new initiatives and relationship building for key resources within the institution.

Demand Creation: Association to the Institution

In recent years, a major change in marketing strategy allowed outreach to significantly increase demand for its programs. Instead of highly emphasizing its own brand (Adventures in Engineering and Science) and maintaining the programs were only "supported" by the University, the program would instead build an image that it was offered by the institution; incorporating the Faculty's brand as its own. This simple change added huge credibility to the programs and catered to parent's need to enroll their children in a reputable educational institution program. Since the uOttawa brand is highly recognized in the city, this also facilitated word of mouth between parents, which ensured that our programs would always maintain maximum capacity.

Institutional Support and Oversight

Just like association to the University brand helped build awareness and demand creation from an external point of view, internal recognition ensured that proper resources could be allocated for its programs. Outreach programs require internal resources to operate that always compete with other organizational priorities. Resources such as classrooms, laboratories, legal services, human resources, financial services are always scarce. Fortunately, at the Faculty level, outreach has been recognized as a major priority and is structured within the organizational structure. This ensures that proper resources are reserved for sustainability and growth.

uOttawa Maker Mobile: A new model for outreach

The foundation that had been developed over the last few years helped scale the summer programs offered at the Faculty. However, it was clear that outreach had the potential to do more than just expose elementary school youth to STEM fields at an early age. Integrated within the Faculty's organizational structure, outreach had the potential to help with recruitment, marketing, fundraising and student engagement. Consequently, new models of outreach were developed and piloted with these factors in mind.

With the profits generated by the summer programs, thousands of dollars were spent every year investing in new rapid prototyping tools such as lasers cutters, 3D printers, and electronics to improve the quality of the outreach programs. However, although youth in the summer programs had the opportunity to learn about these technologies, undergraduate students didn't always have access to these tools. The idea of giving open access to these technologies to students during the academic year when they weren't being used by the summer programs proved to be a highly successful concept. This is how the uOttawa Richard L'Abbé Makerspace was created. Through this makerspace, evening workshops were offered to students to learn about these technologies 3 times a week, and it was clear that there was strong interest not only from students, but also from the community at large. As we spoke to teachers and members of the community, the general consensus was that youth needed more exposure to these types of technologies as they become more and more mainstream. Unfortunately, schools don't always have the knowledge nor the resources to offer this type of content in their curriculum. This presented a unique opportunity to scale the delivery of these workshops, not only on campus, but also in schools throughout the region. The concept for a Maker Mobile that would travel across the city and setup pop up Makerspace workshops was an intriguing one. (see figure 2)

Figure 2. uOttawa Maker Mobile

Setting up the project

The Faculty of engineering already had a solid foundation for the delivery of school workshops, but because of the transportation limitations, workshop content was not of the same caliber as the curriculum delivered through the

Makerspace or summer programs. Consequently, the Faculty decided to invest in a 12-foot cube truck that would have the capabilities to transport all our equipment from one school to the next. The concept for the uOttawa Maker Mobile was inspired by a similar project that was run out of Stanford University called the Spark Truck; travelling coast to coast in the US for a few months of the year. Luckily, the Spark Truck open sourced much of their documentation, so the designs, and logistics had already been tested and documented; allowing us to build upon their initial concept. However, it was clear that the Canadian weather would bring forth its own set of challenges. For example, the frosty winters, and warm summers prevented us from hosting workshops inside the truck, and required the equipment to be stored indoors when not in use.

Unlike workshops in the past, the goal of the Maker Mobile was to offer year-long programming in schools. However, finding instructors for year-long delivery was one of the biggest challenges when recruiting from the pool of undergraduate students (who have full-time course loads during year). The Faculty settled on hiring a mix of part-time undergrad students (usually in their 4th or 5th year with a day off), recent alumni who are still prospecting for jobs, and graduate students who also had lower course loads. We also brought on student volunteers from a newly created Community Service Learning (CSL) program who needed to accrue 120 hours of community engagement as a requirement for their course.

Workshop content

Logistically, the coordination and bookings of school workshops was already aligned with existing processes, so it was fairly straightforward to plan. The delivery, preparation and planning of the content on the other hand required special considerations because of the technical nature of the workshops. Traditionally when going to schools, workshops had been designed to fit in dividable 75-minute units that were flexible enough to coincide with classroom periods. This was not possible with all workshops offered by the Maker Mobile, due to constraints of the technology. 3D printing was a clear example of this, because the technology is slow, and typically requires at least 2 hours for design and printing. Delivery of the workshops also requires more than one instructor because the equipment requires special attention for general operations and troubleshooting. While one instructor focuses on delivering the content of the workshops, the other one can focus on operating the machines. Another reason the workshops required longer blocks of time, was because of their complexity and hands on approach. In a typical Maker Mobile workshop, all participants are engaged in hands on design activities, whereas past workshops relied heavily on presentations and demonstrations.

The curriculum of the Maker mobile was initially developed in multiple stages. Because the project only had two months before the start of delivery, the Maker Mobile utilized a variety of workshops that were already developed for the Makerspace and summer camps. The first few workshops included basic programming, Arduino and 3D printing. It was clear from the initial delivery that many modifications needed to be made in order to cater to the time and grade constraints of each classroom. During the first fall term,

extensive time was spent designing different levels of curriculum for each workshop offered to schools. For example, the laser-cutting workshop included activities tailored for different grade levels that varied in duration and complexity. This provided the instructors with the flexibility to offer workshops that were appropriate for the target audience. It was also important that workshops focused on exploring more than just the technology, and incorporated a multi-disciplinary activity. Coding and technology is not often part of the provincially mandated curriculum expectations, so workshops incorporated concepts pulled from maths and science. The robotics and vectors workshop is a great example of this, as it focuses on teaching Cartesian coordinate systems as participants program a robot that draws images on a 2D plane. This was a great way for student to understand the concrete application of math in the real world.

Unsurprisingly, integrating maker curriculum into an elementary level classroom was much easier than the high school level because teachers at the elementary level teach all subject matter. Often, teachers lack the expertise of certain curriculum areas (especially in engineering and science), and our workshops provided this much needed support. The high schools, on the other hand, required special considerations to meet teacher expectations and needs. Curriculum offered through the workshops had to meet specific deliverables in order remain relevant within the teachers course content.

In order to design workshops that catered to high school needs, a lot of work was done with the involvement of their science teachers. Preliminary workshops were offered to teachers of various school boards to build first and foremost awareness for the Maker Mobile program. This facilitated relationships building with champion teachers who viewed Maker Mobile content as a valuable resource in the classroom. Once this was done, we recruited champion teachers to commit to a curriculum brainstorm session to see how the various technologies could be used to complement different teaching units. The University did this during regular work hours and paid for the substitute teacher's time. Some great insights came out of these sessions such as the inclusion of optics for the 3D printing workshop where participants can design flashlights of focal points to measure the intensity. Overall, engaging teachers in the development of the curriculum was key in order to develop the types of activities high school teachers would value.

Outcomes of the Maker Mobile

Having run the Maker Mobile program for a little under a year, it's evident that the program has created some much needed buzz in the community. The program has already delivered programming to over 14,750 kids and 719 classrooms. Although the school workshop model is not a new one, the addition of the uOttawa Maker Mobile orange truck really helped the program stand out as it created an icon that teachers could talk about. The Maker Mobile program has also helped us develop strong relationships with schools, boards and individual teachers. More importantly, this deepened these relationships allowing us to further develop new models of outreach that require a larger commitment from the schools themselves. For example, our newest initiative introduces rapid prototyping technologies to high school girls through afterschool programs. These

programs seek to have young girls develop their technology skills so they can prototype and design real solutions to real problems in their community. The latest cohort of girls this year have focused on developing wearable technologies and 3D printed water filters that will be used in aboriginal communities. Another model is our newest women ambassador program. This program seeks to recruit young girls from every high school in the region so that they can come together and be women in engineering ambassadors at their school. Girls are brought together once a month to participate in a mix of leadership and technology activities that serve to create a community of women interested in stem in the region. It's clear that without the relationship building that was fostered over the last year of Maker Mobile, it would not have been possible to launch these projects.

Conclusion

Looking back, it's amazing to see the evolution of outreach at the Faculty of Engineering. Starting with a group of students who organised grassroots summer camps in STEM, these programs became overwhelmingly popular with the community. As these programs flourished, a longer term visions for sustainability was required. Full-time staff were put in place to run the day to day operations, and this allowed relationships to develop between the programs and their host institutions. This new formed connection allowed both outreach and the institution to align their visions and goals so that outreach could be incorporated into the formal structure that we have today. This incorporation of outreach within the core mandate of the faculty is enabling new programs like the Makerspace community outreach & Maker Mobile programs to take shape, which are in themselves creating new opportunities for the faculty. It's no wonder why it's a very exciting time at the faculty, and it remains to be seen how outreach will evolve again in the years to come. The uOttawa Maker Mobile initiative clearly demonstrates that engineering schools can develop and offer outreach efforts that can benefit both the institution and the community at large.

References

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