How Can Outreach Foster Further Interest in Stem and Eventually Lead to Careers in STEM?

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Numerous universities, colleges, and STEM-focused organizations co-create outreach activities with secondary education institutions by connecting the work-context with school-science, with the aim to inspire students and motivate them to consider a career in STEM. Although many such activities are being offered, little is known about their actual influence and outcomes. In this article, I approach the experts from STEM outreach field, with backgrounds ranging from not-for-profit science centers, through industry, research institutes, and universities, will address their approach to measuring what impact their STEM outreach programs had on program participants. At the same time, they will address what role equity, diversity and inclusion plays in their programs, how they achieve diversity of participants and in what ways it influences quality of experience for the program participants. Through this article I am bringing together the thoughts of scientists, industry experts, and programs leaders on how outreach can motivate students to pursue careers in science.

Keywords: STEM outreach, STEAM outreach outcomes, equity, diversity and inclusion, education, industry, not for profit, careers

INTRODUCTION

In my role as the manager of programs and careers at the Stewart Blusson Quantum Matter Institute (Blusson QMI) at the University of British Columbia, I have considered the world of outreach an arm of science that can open to reach out to elementary schools, high schools, and under-represented populations of students able to initiate, and, maintain interest, or in some cases even grow it into a career in science. Whatever path a student wishes to take, my goal has been to develop science outreach programs which would engage students of all levels and which would give each member of Blusson QMI (undergraduate students, graduate students, postdoctoral fellows, research staff, faculty, and operations staff) an opportunity to contribute in the way that is the most natural for them and at the same time, meaningful for the students. Moreover, I understood that outreach is best done in collaboration with others, drawing on their expertise and experiences and it is exactly through countless conversations with colleagues and partners from different organizations that the most meaningful programs originate.

Frequent discussions with colleagues about how outreach should be done impactfully led me to deep contemplation about what the characteristics of meaningful and effective outreach programs are and what these programs can do to foster interest in science and encourage careers in science STEM and, at the same time, encourage equity, diversity, and inclusion in STEM.

Universities, colleges, and STEM-focused organizations often develop outreach activities in collaboration with secondary education institutions by connecting the work-context with school-science, with an indirect wishful aim not only to initiate interest in STEM, but also to inspire students and motivate them to consider a career in STEM. Although many such activities are being offered, little is known about their actual influence and outcomes.

I formulated six questions and invited the science experts with backgrounds ranging from not-for-profit science centers, through industry, research institutes, and universities and asked them to share their experiences and approaches to measuring impact of their STEM outreach programs on program participants. Most of the questions are dedicated to what meaningful and effective outreach programs can do to foster interest in science and encourage careers in science while the last question is dedicated to addressing equity, diversity and inclusion of STEM.

These are the short bios of experts I reached out to:

- **Christin Wiedemann, PhD.** is a particle physicist by training who uses her scientific background and analytical skills to dissect complex problems involving large computer software systems in her role as Director of Quality Engineering at Slalom Build. She started engaging in outreach activities as an undergraduate student at Stockholm University, Sweden, where she participated in science fairs and toured high schools to talk about particle physics. Over the last twenty years she has continued to engage in science, technology communication and outreach through speaking engagements and programs.
- **Joel Liman** is the academic advisor for Indigenous students at The University of British Columbia, Faculties of Science and Land and Food Systems. Joel is responsible for running the Cedar Program, and Indigenous STEM Outreach and Mentorship Program focused on supporting Indigenous students in the K-12 system to pursue post-Secondary opportunities in STEM.
- **Theresa Liao** is the communications coordinator for UBC Physics & Astronomy who oversees the department's outreach program, offering workshops and activities for K-12 students. She has organized outreach activities from small (twenty people workshop or summer camps) to large (700-people UBC Physics Olympics, 2000-people solar eclipse observation) many of which she transitioned in 2020-21 to virtual platforms, and developed hands-on activities that students can do using materials available at home. She also plays an active role in the department's Equity & Inclusion Committee.
- **Dr. Olivia New** is the Chief Academic Leader at STEMACES Education, the STEM field experts from from prominent universities who founded the ACES approach to inspire and share with students. Success is proven through engaging learners and guiding them to innovate technologies that they can share with our community at various levels.
- **Jo-Ann Coggan** has been engaged in developing, planning and delivering outreach for over 15 years. She is now involved with a provincial committee of STEAM and Outreach leaders to build a province-wide STEAM learning ecosystem with a main goal to reach all the underserved learners in BC.

Hereby I offer the insights from the STEM outreach experts who themselves chose to answer to the questions that were most connected to their particular work:

1. What was the pivotal moment when you realized: "I want to do outreach?" What led you to it?
    - **Christin:** My STEM outreach started back in junior high school when I was doing mathematics tutoring. I was asked by my teacher to tutor two other children in one grade below me. We had the same textbook and the same teacher, so at the time it was not clear to me what I could do that would make a difference. The *realization*, some sort of *epiphany*, came to me when I found out that I could provide value by presenting the information in a way that they could understand. At the age of fourteen, I felt meaningful in a way I have not experienced before.

Several years later, as an undergraduate student at Stockholm University in Sweden, I got recruited to do different outreach activities, and I had the same feeling. I was not an expert, I did not know everything, but there was a role I could play, where I could add value by taking scientific information and presenting it in a way that *made it comprehensible and exciting* to other people.

When I participated in the mentoring program for "underprivileged" middle school children, I again felt I was doing meaningful and useful work. At that time, I was not familiar with *outreach* as an activity or concept, and even less so science communication or pedagogical skills.

A few years later I came to appreciate how much I got myself out of doing outreach and how much it contributed to my own *professional and personal growth*, advancing my presentation, communication and pedagogical skills. Later, I started thinking about outreach as a responsibility. I felt and I still feel that I have had the privilege of being given access to this beautiful and rich world of science, and it is my duty and responsibility to share that beauty with others, and to make it accessible for everyone.

- **Theresa:** My introduction to outreach started by joining an outreach organization Let's Talk Science to gain some teaching experience. Initially I helped to organize hands-on activities in the classroom and later larger events such as All Science Challenge where ten to twelve grade elementary students or early junior high school students who were enthusiastic about science and learning competed in sciences. The fact that I could support all that was highly gratifying for me.

2. **Natalia:** Passion or interest level becomes different when it has its freedom to express itself in an outreach environment rather than a formal classroom environment. What is special about science outreach compared to how science is formally taught in the classroom? What are some challenges that students face in the way science is taught in K-12 and at university?

- **Jo- Ann:** When I think about this question which is connected with the topic of fostering further interest in STEM or STEAM, four things come to mind: equity, relevance, engagement, and access. Science curriculum does not always take into consideration the location of the learner. It does not necessarily consider the relevant science that is taking place in the specific community that the learner is in, especially when they live in remote or rural communities.

  Science outreach delivery staff are specifically trained to be very engaging, fun and able to find a *wow* factor in the science delivery. We go to the learners into the schools, into the classrooms, into the gymnasium, and wherever we go, we often bring a real-life scientist to the learners to talk about real-life relevant experiences about the sciences that they are actually doing.

  A lot of elementary teachers, for example, do not have a science background which less often happens with teachers in high schools, and having a real-life scientist in a classroom is really important. Two good programs that address all those concerns that I mentioned that are connected to formally taught sciences at schools that Science World in Vancouver in British Columbia (BC), Canada, organizes are Scientists and Innovators in Schools (SIS) and STEAM Ecosystem BC.

  The key point of SIS is having real-life scientists go into the classrooms at the request of a teacher to Science World to find a particular science professional suitable for explaining a particular subject of interest that they teach. Science World has a database of about 240 science experts living all over BC and a teacher has an opportunity to request an appropriate STEM expert for what they teach at a particular time. Within the pandemic time, the program was turned into a virtual program which worked almost as well, however, Science World trains these professionals to deliver engaging talks in the classroom which are hands-on, they have something to touch or make which better connects students to the real-life scientist.

Science World started building a STEAM Learning Ecosystem called Symbiosis and because of current circumstances that we find ourselves in, Science World put the program on hiatus. Since then I have worked most of my time at NGX Interactive, a computer software company that builds digital interactive exhibits for science centers, however, I still continue building STEAM Ecosystem BC which has four regional hubs around the province: Prince George, South Vancouver Island, the Okanagan, and Greater Vancouver area. The leaders meet monthly, collaborate, share resources, connect community A and their resources with community B and share their knowledge with another community, etc., so we do not re-create activities that already exist somewhere else. This way we can stop duplicating outreach activities but rather add onto existing ones.

3. **Natalia:** Live science experiments are irreplaceable and although we were able to find ways to engage our outreach audiences virtually during pandemic, something, I believe, was missing, which leads me to another question: What message should we be delivering when doing science outreach?
   - **Olivia**: Students who model phenomena related to real-world situations learn to appreciate the social relevance of science. They get interested in and start to identify with science as a way of understanding and improving real-world contexts, which can happen at any age. From an outreach perspective, we should accentuate that the goal of building knowledge in science is to explain and predict phenomena by developing general ideas based on evidence. Phenomena change the focus of learning from learning about a topic to *FIGURING out* why or how something happens. For example, instead of simply learning about the topics of photosynthesis and mitosis, students are engaged in building evidence-based explanatory ideas that help them figure out how a tree grows. We should also encourage confidence in *failing* because *FAIL* should be understood as *First Attempt in Learning*. This breeds curiosity which helps them to grasp the topic content.
4. **Natalia**: As you mentioned, Olivia, the student-centered, integrated approach, it is a wonderful approach for a student to see that we can look at, for example, the process of photosynthesis, from biological point of view, chemistry, and even physics point of view, however it requires a very resourceful teacher that understands not only one particular discipline, but is able to approach the phenomenon from different angles and viewpoints of various disciplines. That ties well with this question: How does your role enable you to disseminate science to younger audiences and what have you personally done to do it well?
   - **Olivia**: As the Chief Academic Officer in our organization, I have been instrumental in developing and implementing our holistic method that follows a student from the beginning to the end. Academic and Industrial Partnerships direct the credibility of our curricula, and therefore I have worked directly with our partners such as Richmond and Delta school districts and STEM experts from The University of British Columbia to provide a tactile approach to the content they assimilate, for example *STEMify* school curricula (phenomena approach). Most students who choose to follow a similar path are taught by our experts who are coached through our College Admissions workshops and Industrial Readiness programs developed to give that 'read the end of the book first' approach to their learning to make the journey relevant, and therefore to peak at the outcome.

     We have also developed an Exam and Test preparation program for students based on a unique workshop which uses a digital tutoring approach focusing on researched areas of difficulty. Examples of this are redox reactions to build-up of confidence that leads to interest in Science. STEM-based programs include camps, smarts programs, and school support, emphasizing our engineering design approach, and utilizing modern digital learning tools as required.

These programs are a great success story as they capture and motivate our youngest groups (6 years old children) and lead all the way up to grade 12. Furthermore, they provide a platform for innovative content development, which is diverse, equitable and sustainable. We engage learners and help them to innovate technologies which they can share with the community at various levels. We cannot work as an island, all of it must be connected and we must build together to develop a content that will be hands-on, student-focused and project based and form academic partnerships that bring it alive.

5. **Natalia**: It is important to do outreach activities well and bear in mind particular audiences' goals, which often depend on age. How do you measure or evaluate the impact of outreach in the programs that you developed? Can you define a successful outreach activity for us?
   - **Theresa:** The definition of "success" for outreach programs depends on what your program or activity objectives are. For example, activities for younger children might have the focus to spark children's curiosity and to encourage children to explore scientific subjects further. On the other hand, for older students, the focus might be to develop their problem-solving skills and to consider a career path in science. I will give two examples: our Girl Guides or Brownies British Columbia programs, the goal of which is to get students excited about science through exploratory activities and Physics Olympics which is for grades ten to twelve high school students, giving them an opportunity to look into the practical side of physics and build something or solve problems.

     In these cases, the measurements of success are different. For example, when we see our former Physics Olympiad students in careers in physics or other sciences, it is an excellent initially hidden kind of impact. We have looked at anecdotal stories from parents about young children sharing their hands-on projects with their families and friends, and the excitement the activity brought to the participants. We have also asked the parents whether their children talked about the activities at home, and whether we made an impact on the attitude towards science in them.

     In case of older students, we typically have the option to ask the participants about their personal experience directly, through surveys, both in a quantifiable way (i.e. rate your experience with group work or problem solving) and in a qualitative way, through anecdotes, stories from parents or the participants confirming excitement about an interesting science activity. There are also some indirect ways to evaluate success without surveying participants or their parents.

     An example is our annual high school physics competition where half of the volunteers who used to participate in our activities themselves when they were in high school and are now studying physics or engineering. This demonstrates the success of a program in the form of guiding students towards a STEM career and stimulating students' passion in the science subjects, and hence fulfilling the objectives of an outreach activity. So, the key is to have clear objectives for your outreach programming, and then design the evaluation around your objectives to determine the success of your program.
6. **Natalia:** It is important to realize that not all students have equal opportunities to engage in science, and therefore are underrepresented in science. How can we address the issues of underrepresentation in STEM fields? What role can science outreach programs play in addressing disparities in STEM fields?
   - **Joel:** This is a new, emerging topic in STEM outreach and in some ways, and to a certain extent it is yet to be determined. When we are talking about social engineering of current realities which may be based on systemic issues, I think it is really important to understand that this is long-term work that requires a lot of partners, a lot of people working together to identify the issues at hand.

The main project I work on in terms of outreach work is an outreach activity that begins working with Indigenous youth at the age of eight. It has been happening for about fifteen years now and we have seen that participants of this outreach activity later became applicants who were accepted at The University of British Columbia (UBC), and now have even graduated from UBC. Therefore, from an anecdotal perspective, there are definitely aspects of outreach that can affect student trajectories.

In the context of underrepresentation, experiencing the power of science outreach at a very young age can affect someone's orientation in life. This is, in my mind, an opportunity for STEM outreach in the form of really looking at how a young student's mind is oriented and how they can picture themselves as a scientist, as someone who is engaged in this type of learning.

Being involved in recruitment and admissions, I also dealt with students who had gone through our outreach program and applied to UBC but whom we had to turn away because they did not have the foundational science marks to gain admission to our institution. Having seen that, I reflected on how important partnerships are.

From an outreach perspective, we 'fly in' and do something fun and engaging but those continued partnerships and everyday work and how we partner with schools to ensure that there is a network of academic support, are really crucial conditions. It is important to implement and maintain those nuts and bolts approaches to really develop student skills and everyday work to provide resources for a student to be ready to study science at a postsecondary level is not something where outreach is a magical solution to changing how students are represented at the university; it requires robust partnerships.

- **Natalia:** One thing to add to what you outlined is the function of role models, examples to follow in sciences that marginalized students can see to realize that it is possible that one day they can be one of these scientists.
- **Joel:** Indeed. When we do have those role models, we should reach out to them and let young students know about their achievements and success stories. For example, I am honored to have worked with many Indigenous students who achieved degrees in sciences and went onto undergraduate school or medical schools or landed in other great career opportunities. It is crucial to celebrate such achievements and give these experts opportunities to mentor and provide that modeling for younger people.

SUMMARY

Universities, colleges and not-for- profit sectors all organize STEM outreach for varying audiences in terms of age and motivation. The interviewed experts touched on quantitative but elaborated mostly on qualitative measuring of success of STEM activities. Measuring outreach success should be tied to the goals of activities for particular age and interest groups. While sparking a moment of inspiration is an appropriate qualitative measurement proof in terms of younger students, turning it into an interest to study STEM and pursue a STEM career is a suitable qualitative measurement tool for students of higher school levels. Doing outreach due to personal satisfaction, connecting science with a community, collaboration, figuring out why/ how phenomena happen, or ability to understand how a student mind works in terms of building their motivation all contribute to doing it well which inevitably influences learners. Creating networks connecting schools with industry, research, and not-for- profit organizations where all share information and learn from one another contributes to doing meaningful and impactful STEM outreach.

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REFERENCE

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