EXPLORING THE STATUS OF SCIENCE OUTREACH IN SCIENCE TEACHING

by

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Abstract

Despite the continued demonstration of the importance of science outreach programs to inspire student interest and motivation in science, my experience is that the science outreach programs are currently underutilized in schools. This is besides the fact that many stakeholders including students, teachers, parents, scientists, the community and society can potentially benefit from science outreach programs. With most studies focusing on assessing the impact of outreach on students, there remains a gap in research on the processes that are undertaken by teachers and outreach providers to create these opportunities.

This mixed-methods study used scientist-in-residence outreach model, as reference because of its prominence in promoting science outreach in attempt to address this gap by investigating teachers’ science outreach practices in schools to better understand the decisions they make about the place or status of science outreach programs, in their teaching. The study objectives were to (1) investigate the science outreach practices of science teachers, focusing on how outreach is integrated into curricular and instructional practices; (2) explore how teachers and outreach providers implement various science outreach models, including any potential challenges to this; (3) propose a model that better utilizes the efforts of both these stakeholders, teachers and outreach providers, with the aim of improved communication, that both teachers and outreach providers can use to inspire student interest and motivation in science.

This study took a mixed methods approach, using a quantitative survey-questionnaire and qualitative interviews to elicit information on the practices of both elementary and secondary teachers regarding various forms of science outreach. Interviews occur with teachers, scientists, and other members of non-profit organizations coordinating various science outreach programs. Organizations that use the scientists-in-residence outreach model were of particular interest.
Analysis of the data corpus revealed engagement, access, costs and comfort with science as the challenges for implementing outreach programs. Moreover, attitude, delivery and use of a facilitator were determined as ways to overcome these challenges. Based on these insights an emergent model is proposed to assist both teachers and outreach providers in inspiring student interest and motivation in science through outreach programs.
Preface

This work is the result of a collaboration between myself and my thesis supervisors: Dr. Marina Milner-Bolotin and Dr. Samson Nashon. The purpose and goals were my own, as was the creation of the survey-questionnaire and interview questions. I conducted all the research, performed the data analysis and prepared the manuscript. Throughout this process I was guided, given feedback and direction from both supervisors.

Ethics approval was granted on November 22, 2011 by the University of British Columbia’s Behavioural Research Ethics Board (BRED), Certificate Number H11-02662.
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To my wonderful friends: Bingbing Li, Stella Chow and Elizabeth Love. Thank you for your help and support in my studies, and all the good times we had together.
Dedication

To my father, Dr. Lawrence Friedman, with love

Thank you for your love and support, both financial & emotional

That made this degree, and time of success and healing, possible.
Chapter 1: Introduction

1.1 The Problem

Today’s teachers are being called upon not only to offer opportunities for students to experience and acquire scientific knowledge and skills but also to engage students in activities meant to encourage them to pursue science and science related professions in post-secondary programs (Alberts, 2009) It is anticipated that in the next decade or so, the wave of baby boomer retirements and the increasing demand for a knowledge-based population would fuel demand for individuals with science, technology, engineering and mathematics (STEM) degrees (Association of Universities and Colleges of Canada, 2007). The question arises regarding how to motivate students to ensure this need is met. According to Bruce & Bruce (1997), children who choose a career in science or math, do so before the ninth grade. Therefore, it is important to examine various methods, of which science outreach is one, that have an aim of encouraging students to study sciences at both high school and post-secondary levels.

This study adopts the term of science outreach to describe an activity that involves any individual(s) from the scientific community, including practicing, future or retired scientists, engineers and innovators, (Vitale, Romance, & Dolan, 2006) in “inspiring a lifelong interest in science for children and youth and creating a greater awareness and understanding of science” (Edmonton Science Outreach Network). Science outreach, for the purpose of this thesis, might take on the form of web blogs, podcasts and wikis, technologies as media often used by scientists to engage the public. It often occurs outside of the classroom in informal learning environments, such as museums, national parks, science centers, zoos and aquariums (Vitale, Romance, & Dolan, 2006).
Classroom outreach activities are shown to positively impact students’ interest in science and hence their eagerness to learning science, thus leading to an increased likelihood of pursuing a career in this field (Laursen, Liston, Thiry, & Graf, 2007b). However, research indicates that only 17% of science outreach is done in a classroom and only 8% involves the community youth, of both elementary and secondary students (Let's Talk Science, 2007).

Scientists are increasingly being called upon to communicate science and promote scientific literacy (Nature Neuroscience, 2009). Alan Leshner, CEO for the American Association for the Advancement of Science (AAAS), states as most major societal issues have an aspect of science to them, it is the duty of scientists to make clear that science is central to each person (Leshner, 2008). Scientists must respond to concerns about how scientific advances will affect personal lives and issues that matter to the community. Without this basic literacy, students today will not be prepared for making decisions regarding healthcare, the environment, and many other issues related to their personal and professional life (Kesidou & Koppal, 2004).

As public funding supports scientific research, it is the responsibility of scientists to share their findings in a meaningful way with fellow citizens (Vitale, Romance, & Dolan, 2006). Further, with the rise in demand for high skilled workers with degrees and experience in STEM, organizations, governments and individuals want to encourage today’s youth to enter and study these domains.

As discussed by a panel at the North-West Area Conference of the National Science Teachers Association (NSTA) meeting in December of 2011 in Seattle, Washington, one solution is to create an authentic collaboration between businesses and other science, technology, engineering and mathematics (STEM) professionals (Smith, Rice, Lyons, & Novy-Hildesley, 2011). This partnership calls for engagement and a time from these government and private
outreach providers, as opposed to a solely financial, commitment. However, given that Canada is a very large, yet scarcely populated country with diverse needs, the challenge is to create a model that is not only sustainable but also relevant to each community and school. Therefore, science outreach should provide opportunities for students and teachers to engage in science in a way that builds up momentum to create a cycle of self-sustaining collaborations. In the context of this study, a self-sustaining relationship is one between teachers and scientists that would require a minimum support from outside sources. Students are the intended beneficiaries of the outreach, yet it has been shown that both the teachers and scientists themselves benefit from engaging in outreach activities (Laursen, Liston, Thiry, & Graf, 2007a; Lockhart & Le Doux, 2005; Mumba, Mejia, Chabalengula, & Mbewe, 2010). With most studies focusing on measuring the impact of science outreach on students, there remains a gap in research focusing on the processes that are undertaken by the scientists and by the teachers in providing these opportunities and partnerships (Felix, Hertle, Conley, Washington, & Bruns, 2004).

1.2 The Research Questions

In this study, I am focusing on exploring and understanding the processes for (including barriers to) implementing science outreach by the two stakeholders: science teachers and outreach providers. Hence the following questions:

1. What post-secondary educational backgrounds and contexts of work are represented among the participants – science teachers and outreach providers? How can these data inform decisions about potential target of science outreach?

2. In what ways and to what extent have the participants been involved in science outreach and what steps do they follow in planning and implementing outreach activities for
inspiring a lifelong interest in science for children and youth and creating a greater awareness and understanding of science? What are the barriers encountered by the participants in this process?

3. What emergent model would be appropriate, for use by both teachers and outreach providers, so that the outreach efforts allow for better utilization of science outreach opportunities?

1.3 The Study

1.3.1 Outreach Model for the Study

There are many stakeholders who potentially provide or benefit from science outreach: students, teachers, parents, scientists, the community, and society. Various approaches to science outreach exist (Vitale, Romance, & Dolan, 2006). However, this study will limit the focus of science outreach to the model whereby the scientist enters the classroom. I decided to pursue research in the field of science outreach in the hopes of better understanding the steps organizations take, as well as the educators who partner with them to bring scientists into their classroom as an educational instructional tool. My study’s focus (Figure 1) involves outreach program collaborations between a teacher within the school, and the scientist as a representative of an outreach provider.
Through my research, I hope to gain an understanding of current trends in science outreach. Further, I seek to gain a better understanding of the reasons why educators include or omit science outreach into their teaching practices. My study’s goals are to: 1) elicit and interpret the processes outreach providers and teachers engage in as well as the barriers they encounter during the planning and implementation of outreach in classrooms; 2) profile the stakeholders’
level of science education with a view to assessing potential benefits of partnering in outreach program delivery; 3) outline the components, key steps and points of concern in a way that harmonizes the intentions of both teachers and outreach providers; 4) propose a template for future outreach service delivery.

1.3.2 Researcher’s Personal Motivation for the Study

As both a science teacher and a scientist, I believe that science outreach is an important tool for motivating and educating today’s youth to enter Science, Technology, Engineering and Mathematics (STEM) fields, gain important skills and increase general scientific literacy and knowledge. With both of my parents being scientists, while growing up I had access to many outreach opportunities such as trips to science centres, museums, and camps. I had personal ties to hospitals and universities and became familiar with a variety of scientists; I was greatly influenced to study and pursue science in high school and in my post-secondary studies. Unfortunately, not all students have access to positive science role models and even fewer students are presented with opportunities to engage, and interact with various members of the scientific community. When teaching at an international school in Uganda from 2008-2010, I was inspired to bring scientists from the community into the classroom to engage students in science, and become aware of the scientific community around them. Fascinated by cutting edge research, especially concerning HIV/AIDS and malaria, occurring around me, I organized a daylong science symposium for the entire high school. Upon my return to Canada in 2010, I again became involved in science outreach. As an adult, I reflect on the many skills and learning experiences that I gained as a result of my upbringing. I feel it is important that I give back and help the education of the scientific community, and pass along the knowledge and positive
perspective that my privileged position afforded me. This can be done through the participation, promotion and research of scientific outreach.

I drew upon knowledge of my role both as a scientist and high school educator as the two connected my study. Though (Bartunek & Louis, 1996) discuss this approach, whereby there are two members of the team (one an insider, one an outsider), I simultaneously occupy both roles. As an insider, I played a role of a long-term member of both scientific and teaching communities when not involved in this study; whereas as a graduate student at the Faculty of Education, who has received formal training in social science research methodology, I played a role of an educational researcher concerned with uncovering generalizable knowledge about science teaching and learning. I attempted to occupy the space between, as described by Dwyer & Buckle (2009), so that I can reconcile these two different roles rather than one or the other. I employed a survey-questionnaire which allows for a large sample collection of quantitative data anonymously. Interviews allow me to make use of these dual roles, and collect more in-depth, qualitative data. A mixed methods approach is undertaken with the intention of integrating both types of data at the level of analysis in order to provide more powerful insights about the process of science outreach than either could produce alone (Caracelli & Greene, 1993).

1.3.3 Significance of the Study

Despite the continued demonstration of the importance of science outreach programs to inspire student interest and motivation in science (Koehler, Park, & Kaplan, 1999; Laursen, Liston, Thiry, & Graf, 2007a), my experience is that outreach programs are currently underutilized in schools. Students, teachers, parents, scientists, the community and society may also potentially benefit from science outreach programs. With most studies focusing on
measuring the impact of outreach on students, there remains a gap in the research on processes that are undertaken by the various stakeholders to provide these opportunities.

There is a demand for students to enter STEM fields (Association of Universities and Colleges of Canada, 2007), as well as for scientists to increase their participation in service – raised interest, awareness, and the promotion of scientific literacy (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005; Christian, 2003; Holland, 1999). The outcomes of this study have implications for the way both teachers and potential volunteer scientists invest in science outreach especially for youth in high schools. This study will offer insights into how potential challenges to science outreach can be overcome as a way to inspire future outreach programs.

1.3.4. Research Methods

This study describes how and why both science teachers and outreach providers plan and implement science outreach, as well as barriers to implementation. This research consists of two primary methods of data collection: a quantitative questionnaire/survey and qualitative interviews. Science teachers, at the primary, intermediate, secondary, and post-secondary level were asked to complete the survey anonymously online. On the basis of these results, certain individuals were invited for interviews. These individuals were science teachers, scientists, or a person involved in successful science outreach in some capacity. These interviews were conducted once, and audio recorded. In this study, the researcher was also the interviewer.

The participants were drawn from across Canada, with interviews occurring in person in around Vancouver. Due to travel constraints, interviews set in other locations, were conducted over the phone.
1.3.5. Data Analysis

The audio recordings from the interviews were transcribed verbatim and analyzed. The analysis of the data was based on grouping and coding of the transcripts according to common themes (Appendix K). Decisions about the coding and grouping were made on the basis of the literature about science outreach. The 19 coding categories are presented below in a Table 1.

<table>
<thead>
<tr>
<th>Coding Symbol</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>MinEd</td>
<td>Ministry of Education</td>
</tr>
<tr>
<td>Org</td>
<td>Organizations</td>
</tr>
<tr>
<td>Del</td>
<td>Delivery of material</td>
</tr>
<tr>
<td>Sc</td>
<td>Scale</td>
</tr>
<tr>
<td>Tec</td>
<td>Technology</td>
</tr>
<tr>
<td>MImp</td>
<td>Measuring Impact</td>
</tr>
<tr>
<td>Bar:C</td>
<td>Barriers - Cost</td>
</tr>
<tr>
<td>Bar:T</td>
<td>Barriers - Time</td>
</tr>
<tr>
<td>Bar:R</td>
<td>Barriers - Engagement</td>
</tr>
<tr>
<td>Bar:CwS</td>
<td>Barriers - Comfort with science</td>
</tr>
<tr>
<td>Bar:A</td>
<td>Barriers - Access</td>
</tr>
<tr>
<td>Ben:St</td>
<td>Benefits Students</td>
</tr>
<tr>
<td>Ben:Sc</td>
<td>Benefits - Scientists</td>
</tr>
<tr>
<td>Ben:T</td>
<td>Benefits Teachers</td>
</tr>
<tr>
<td>NI:BE</td>
<td>Negative Implications - Bad experiences</td>
</tr>
<tr>
<td>NI:A</td>
<td>Negative Implications - Accountability</td>
</tr>
<tr>
<td>PS:A</td>
<td>Promoting science - Attitude</td>
</tr>
<tr>
<td>PS:F</td>
<td>Promoting science - Funding</td>
</tr>
<tr>
<td>PS:E</td>
<td>Promoting science - Engagement</td>
</tr>
</tbody>
</table>

Table 1: Coding of categories for interviews

1.4 Organization of the Chapters

There are six chapters in this study. The first three chapters lay out the foundation on which the study was based. They include the introduction (Chapter One), literature review (Chapter Two), and methodology (Chapter Three). Chapter Four discusses both the survey and the interview data and analysis. The survey elicited general trends in schools and perceptions of
teachers regarding science outreach. The interviews inquired into the personal perspectives of outreach providers and teachers. Chapter Five discusses the outcomes of the analysis. Lastly, Chapter Six presents the conclusions and recommendations of this study, as well as the implications for practice, curriculum and further research.
Chapter 2: Theoretical Framework and Literature Review

Science outreach is gaining in popularity with teachers as a method of delivering and supplementing the prescribed curriculum in educational settings. This chapter discusses the Situated Cognition theory (Lave & Wenger, 1991) as the theoretical framework through which guides this study. Situated Cognition theory discusses how the nature of education is changing where a key role of the teacher is to provide opportunities to engage with happenings in the area being studied, and to allow students to explore “real” stuff (B. C. Bruce & Bruce, 1997; Let's Talk Science, 2007). The Situated Cognition theory connects to Dewey’s educational theories on experience and education, which propose that teachers to be a partner in the learning process, guiding students to independently discover meaning in the material (Dewey, 1998). This inquiry-based model of education will be discussed in detail later in relation to science education. It will show how science outreach is an innovative venue for students to engage with real life applications of science that build upon the learning outcomes within their schooling.

2.1 Theoretical Framework

To analyze the process of science outreach implementation by science teachers and organizations, I will use the Situated Cognition framework (Lave & Wenger, 1991). The theory premises that communities of practice are formed by people who engage in a process of collective learning in a shared domain. According to Alberts (2009) students will be more likely to think and act like real scientists in the field if they interact and engage with members of the scientific community. Thus Situated Cognition framework views the collaboration between scientists, teachers and students in the classroom as a community of practice, and each will gain in knowledge as they interact. Dewey states: “The teacher… is there as a member of the
community to select the influences which shall affect the child and to assist him in properly responding to these influences” (Dewey, 1998). The scientist is actively involved in the practice of science research, while the teacher is actively involved in matters of pedagogy. Each can learn from the other as they interact. Beliefs, behaviours and collaborative efforts between these two stakeholders will be examined to explore the driving forces behind teachers’ willingness to participate in science outreach, in addition to the benefits to students.

2.2 An Inquiry-Based Model of Education

Increasingly, there is a move away from the traditional teacher-centered lecture style of teaching towards a more contemporary student-centered approach (Alberts, 2009; D. Hodson & Hodson, 1998). This contemporary approach places more emphasis on collaboration and inclusivity, and redefines the roles of both the student and the teacher by engaging the student in “active learning” (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008), hence the Inquiry-Based Learning model. In this model, the role of the teacher changes from the expert telling the answers, to an facilitator of learning; there is a shift towards that of a coach or facilitator, with the focus on participation and negotiation rather than direction and instruction.

This model would also change the roles of the students in regards to their learning. According to (Abbott, 2010), the inquiry allows educators to take advantage of the innate learning ability of young people in a more open, exploratory, active-learning environment where they learn by doing, not just by reading and listening. Ideally, students would be empowered and inspired to “pursue learning both in school (formal learning) and outside of school (informal learning)” (Schwab, 1980). It is increasingly being recognized that society cannot rely on a single event to inspire future scientists, but must provide a range of opportunities for excellent
science education, in school and outside of it (Laursen, Liston, Thiry, & Graf, 2007a). Students’
outside-of-school learning experiences are also critical. However, not all students have the
support structures in place that will allow involvement in outside learning. Science outreach,
which involves multiple stakeholders such as teachers, scientists, students, parents, and
community, offer various opportunities, both inside and outside of school, to encourage active
science engagement.

2.3 Transforming Science Education

In respect to science as a discipline, experts such as Bruce Alberts, Editor-In-Chief of
Science, are looking to redefine science with the focus on gaining scientific habits of mind, as
opposed to recall of facts (Alberts, 2009). The current state of science and mathematics
education has increasingly attracted the attention of not only policy makers and educators, but
also scientists and engineers. The goal is to make it easier for teachers everywhere to be able to
provide students with “laboratory experiences that mirror the open-ended exploration of
scientists, instead of the traditional “cookbook” labs where students follow instructions to a
predetermined result (Alberts, 2009). A teachers’ involvement with scientists can provide
specific examples of scientific investigations that differ from their view of the “scientific
method” and single variable experiments with known outcomes (J. Pegg & Gummer, 2010).

More than 30 years ago, Joseph Schwab (1980) emphasized the need to change how educators
currently teach science. Schwab also noted that science itself has changed, due in part to the
greatly increased rate of data accumulation and processing. It is important to teach students that
science is not a rigid body of knowledge, but rather a way of figuring things out based on reliable
information.
Teachers are already facing large classes and diminishing resources, and even the most dedicated science teachers could have difficulty providing learning experiences that engage students and reflect the latest scientific developments (Pegg & Gummer, 2010). Further, according to Pegg and Gummer (2010), many teachers at the elementary and the secondary levels have never been directly engaged in scientific research. Yet, one of the goals of an education system is to expose children to high-quality science inquiry in each year of elementary and middle school, supported by prepared science specialists (Alberts, 2009). Children who choose a career in science or mathematics, do so before the ninth grade, and therefore it is important to ensure that all K-8 science teachers are involved in this model of education (Bruce, Bruce, & Conrad, 1997). In order to address this problem, we should build a strong coherent and cohesive argument in favour of the development, in partnership with many organizations already involved in this area, of more resources to support science learning (Walker, 2011). Research experiences, where teachers do original scientific research in a scientific laboratory have been found to increase teachers’ content knowledge. More importantly, these opportunities allow teachers to experience authentic inquiry, interact with scientists and speak to them about their activities, identities, artifacts, knowledge and practice (Pegg & Gummer, 2010). As the Situated Cognition framework states that understanding is inseparable from context, activity, people, culture and language. It is crucial for a teachers’ continued grasp of science and the scientific community (Lave & Wenger, 1991). In addition to a teachers’ experiences, there is an assumption that the involvement of scientists in K-12 education, where professional scientists come into the classroom would allow students to be exposed to an inquiry-based learning process from those working at the bench (Nature Neuroscience, 2009). Given the current burden on educators, some believe that teachers need to be better rewarded for efforts to implement a more
inquiry-based culture in their classrooms (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005; Mumba, Mejia, Chabalengula, & Mbewe, 2010; Nature Neuroscience, 2009). Though science outreach can support teachers in their efforts to create inquiry-based learning, it is felt that, for the most part, such changes must come from within the education system (Nature Neuroscience, 2009).

2.4 Benefits of Science Outreach

In order to help scientists interact effectively and efficiently with teachers and students, it is necessary to support scientists in their outreach efforts. Training and teaching scientists to work with students and other members of the public, is truly important for learner engagement as well as successful communication between scientists and the general public (Leshner, 2008). However, engaging in outreach has other far-reaching benefits for the scientists themselves. Scientists at all levels, including graduate students, may benefit from working with teachers who are experts at communicating science to non-technical audiences. A variety of jobs in science require strong teaching and communication skills; for example, marketing and sales in biotechnology or pharmaceutical companies, public relations in scientific societies, and writing or editing positions with scientific journals (Vitale, Romance, & Dolan, 2006). Science outreach may also provide opportunities for scientists to learn and practice these skills, potentially translating to success in the workplace. Even within academia, scientists are required to communicate, by sharing results and research findings during group meetings, or reporting research results to the broader scientific community (Vitale, Romance, & Dolan, 2006). According to Schwab (1980), the process of social change and demands made on leadership are now such that the specialist can no longer function as merely a specialist. This is even more
relevant in the 21st century. Scientists today must understand the outside of their area of narrow specialization, adapt their knowledge to these problems, and being able to work with specialists from many other fields in forging a union of their contributions (Schwab, 1958). Contributing to science outreach gives scientists important skills to function within their discipline, the workplace but also within a larger society.

Teachers, as specialists at imparting both knowledge and skills, can benefit from uniting with scientists. In a qualitative study (Pegg & Gummer, 2010), 41 teachers were engaged as co-investigators along with scientists in an authentic science experience. These interactions allowed teachers to directly observe the role that communication among scientists plays in formulating and negotiating conclusions from data. Further, it has been found that these benefits from the interactions that science outreach provides, are not linear. Studies conducted by Bruce and Bruce (1997), Conrad and Huang (1997) called Project SEARCH (Science Education and Research for Children), was designed to teach science and foster positive attitudes towards science. It employed active learning in both the classroom and after-school settings, and used undergraduate science majors in the role of “expert” (Figure 2).

Figure 2: Initial model for outreach flow in the SEARCH project.
The initial model predicts a unidirectional flow of information and influence from one stakeholder (the outreach provider) to the various other stakeholders (teachers, students and the school community). However, it was found that the benefits and information flow were multidirectional, creating a network shown in Figure 3.

![Figure 3: Network flow of benefits and information realized through SEARCH activities](image)

In this study, there were many benefits for the various stakeholders, including the undergraduate science students, arising from their participation in the project. However, the undergraduate science majors were accredited with course hours for their participation. The question arises then, of how many of these university representatives would have participated in the partnership with the schools, without this initial incentive?

**2.5 Science Advocacy**

Various approaches exist to entice outreach organizations, and scientists in particular, to participate in outreach. Many feel that they should be rewarded for participating in these efforts; one option would be to give young scientists teaching credits for participating in these outreach efforts (Nature Neuroscience, 2009). Others feel that this should count as service, and either be recognized by awards, or counted in evaluations; for example, the attainment of tenure. Alan
Leshner, CEO of the American Association for the Advancement of Science (AAAS), advocates for a different approach compared to previous traditional models (Leshner, 2008). He states that global issues must be made meaningful to society at the local level, with scientists and other citizens recruiting non-scientist friends and neighbours to promote science funding to decision makers. To improve science instruction, and encourage the next generation of youth to enter STEM, science must have supporters at both the national and local levels. While this statement is in reference to funding, this approach is equally applicable to the issue as a whole: successful science advocacy needs both national and local support.

2.6 Barriers to Science Outreach

Various methods of support for K-12 science outreach programs exist, and at the national level this usually is in the form of grants. For example, in 1999 the Howard Hughes Medical Institute (HHMI) awarded $12.6 million to a variety of medical schools, biomedical research institutions, teaching hospitals and academic health centers, for the purpose of increasing young people’s and teachers’ exposure to, interest in, and understanding of science. In a follow-up to the four year grants (Felix, Hertle, Conley, Washington, & Bruns, 2004), the difficulty of assessing the benefits of outreach, and attributing them to any one factor was raised. Indeed, a major obstacle to support for science outreach programs is the need, usually by those designing and running such programs, to provide results or evidence of a positive outreach impact. However, long-term outcomes are inherently challenging and expensive to evaluate due to the many variables involved (Laursen, Liston, Thiry, & Graf, 2007b). This study will seek to address this problem by collecting data on the barriers to science outreach from the perspective
of various teachers and outreach providers, as opposed to examining the outcome of one specific experience.

Although financial support is important for outreach, other challenges also exist. Many believe that the issue is not so much a lack of resources but a dearth of coordination and access to existing tools. In a confidential study conducted by Genome BC, a participant stated: “People like websites but you run into the same issues with the multi-media kits – they must always be accessible and up-to-date” (Walker, 2011). A portal-type site could link teachers and students to the wealth of material currently available on the worldwide web but also act as a hub for partnering outreach organizations such as corporate partners who already support science education in some way, such as Amgen, MerckFrosst, Pfizer Canada, and Life Technologies in Canada.

This review of the literature demonstrates the many benefits to using science outreach as an instructional tool within the classroom. Past research indicates the need for more analytic research into the processes that are undertaken to provide these opportunities by outreach providers, and how they are found and utilized by teachers within the classroom. Identifying these factors and listening to the experiences of both teachers and outreach providers will provide useful insights of the various stakeholders (teachers, students, parents, the community and scientists) who all seek and stand to benefit from harmonized and increased utilization of science outreach. Chapter 3 will discuss how and what data were collected in this study in order to address this gap in the literature.
Chapter 3: Research Methodology and Methods

To investigate the research questions, I employed a mixed methods research strategy (Newman, Ridenour, Newman, & DeMarco, 2003), which combines quantitative and qualitative paradigms. The quantitative paradigm has been characterized as regarding reality as single, objective, and fragmented (Creswell, 2010). In contrast, the qualitative paradigm, explores meanings of experiences, and how people make sense of their lives and the world. While these paradigms are based on different worldviews, logic, and views of reality, Caracelli and Greene (1997) and Johnson and Onwuegbuzie (2004) identify several parallels between quantitative and qualitative research. These parallels emphasize that the criteria of trustworthiness (or validity) in qualitative research (Guba & Lincoln, 1989; Lincoln & Guba, 1985) include the notions of credibility and transferability that are similar to the concepts of internal and external validity used by quantitative researchers (Johnson & Christensen, 2000; Johnson & Christensen, 2008). Furthermore, both quantitative and qualitative researchers attempt to minimize confirmation bias and other sources of invalidity (or lack of trustworthiness) that exist in every study (Sandelowski, 1986). Finally, both quantitative and qualitative methodologies “describe their data, construct explanatory arguments from their data, and speculate about why the outcomes they observed happened as they did” (Sechrest & Sidant, 1995).

3.1 Sources, Setting and Methods for Data Collection

The purpose of the study is to investigate science outreach practices by science teachers to better understand the reasons for decisions educators make about inclusion of science outreach programs into their teaching, with special focus on scientist-in-residence outreach model. The phenomenon of science outreach in the classroom as a whole, including teachers’ and scientists’
educational practices, the difficulties encountered in this process, and effective ways of addressing them, were studied. Using my own experiences as well as the literature, a survey-questionnaire was created. This survey-questionnaire was first administered to inquire into teachers’ practices regarding science outreach and followed in-depth interviews. These qualitative semi-structured interviews would be used to explore themes that emerged from the quantitative survey. Before interviews, observations of the procedures for outreach and relevant documents were analyzed to determine the general procedures and policies in place regarding outreach. The choice of qualitative research followed from my goal to investigate the process while paying careful attention to the wealth of information that might elude studies relying solely on survey/questionnaires.

The following sections (context, time and length of study, participants, methods of data collection, data analysis, reliability, validity and limitations of the design) shed light on the research methodology employed in the study.

3.1.1 Context

The study was conducted in the context of the scientist-in-the-classroom model of science outreach. There are four reasons for situating the study in the classroom model of outreach. Firstly, this outreach model directly affects today’s youth, as opposed to other members of the public, and there is currently a big need to motivate and encourage students to enter STEM fields. Secondly, this outreach model allows for recurring encounters between teachers and the volunteer scientist, and the establishment of strong community partnerships. Thirdly, I had access to and rapport with the three organizations supporting this outreach model through my active participation in various outreach initiatives. Fourthly, scientist-in-the-classroom is a
category of outreach that can be implemented in any school community, not just in urban
centres, as it does not rely on a specific institute nor incur large travel costs and other added
difficulties. Therefore, it was decided that this study would focus on science outreach where a
scientist comes into the classroom or school.

Outreach providers, such as *Let’s Talk Science*, and *Telus World of Science* were of
particular interest for the perspective of ‘the scientist’. These organizations have a long history,
prominence but also strong ties to the University of British Columbia through the involvement of
science graduate students and professors as volunteers. Further, these locations are part of an
overall national institution that receives federal funding. Therefore, the results obtained in this
study are applicable to similar or equivalent branches of outreach across all of Canada. Each
organization runs various programs, of which scientist-in-the-classroom model is one.

### 3.1.2 Participants

Science teachers, both elementary and secondary, were recruited to complete an online
survey-questionnaire. These teachers were recruited through various listserv from the following
organizations: NSTA (National Science Teachers Organization), BCScTA (British Columbia
Science Teachers Association), STAO (Science Teachers Association of Ontario) and AAPT
(American Association of Physics Teachers). These are the largest science associations from
which recruitment of participants was made.

The results of this survey helped me better understand the factors relating to participation
or non-participation in science outreach in the classroom by teachers who teach science across
North America and to get a broad perspective from educators regarding the pursuit of outreach
activities. These data were used as a point of departure for further investigation through
interviews. Participants for interviews were selected on the basis of their experiences corresponding to emergent themes found in the survey. For example, scientists involved in Science Fairs were chosen, given the popularity of this outreach practice as demonstrated in the survey. This specific use of sampling, where the participants of the interview were nested within that of the survey, also helped to ensure a cohesive study (Yin, 2006). Once participants were identified, a recruitment email was sent to them with information about the study and an attached consent form (Appendix B). Those participants who responded positively were interviewed. These interviews provided in-depth data on how teachers and scientists got involved in science outreach, and why they have continued to be involved for many years. All interview participants have been involved successfully in science outreach for a minimum of ten years, giving them a solid foundation of experience from which to provide data. Further, data on perceived benefits and barriers to outreach, as well as methods for outreach implementation were collected from these stakeholders.

3.1.3 Methods of Data Collection

3.1.3.1 Mixed method research

A mixed method approach incorporating both quantitative and qualitative methods in the design, data collection and analysis was chosen to address the research questions for this study. Initially, when deliberating on the various methods of data collection, it was decided that a survey-questionnaire would be useful for getting information on teachers’ outreach practices, both current and past, and also for getting a general sense of attitudes towards outreach. These results from a large subset of teachers were then used to inform and focus the subsequent interviews. These interviews helped to provide depth and a personalized voice to the study.
Further, it was felt that combining the data from the survey (quantitative aspect) and the interviews (qualitative information) would provide significant advantages thanks to the following three methods: triangulation, complementary purposes and development (Caracelli & Greene, 1993). *Triangulation*, would allow for corroboration, convergence and correspondence of results across the different methods. Results from the survey are enhanced and clarified by the results from the interviews, providing a *complementary purpose* to the two mixed methods. Finally, the results of the survey would help develop and inform the direction of questioning for interviews, providing a *development purpose* (Caracelli & Greene, 1993). The same set of research questions was used for both the quantitative (survey) and qualitative (interviews) procedures of the mixed research to ensure that an integrated study took place (Yin, 2006).

3.1.3.2 Survey

The online survey software and questionnaire tool, SurveyMonkey (www.surveymonkey.com), was used to create a web-based survey and to collect the survey data. Creating the online survey was extremely straightforward and allowed for a simple but attractive layout (Figure 4).
Some of the advantages of a web-based survey were that it provided quick responses, automated data collection, convenience for those participants filling it out, and access to a larger sample, in both terms of numbers and location, that would not have been accessible otherwise. One disadvantage with the survey was that it did not restrict participants from completing it more than once. However, the IP addresses for the respondents were recorded and this did not occur. Further, data from participants who failed to complete the survey were completely discarded.

The survey (Appendix B) consisted of 17 questions. Two questions were administrative, three of the questions provided demographic information, six questions probed various outreach possibilities, and seven questions were based on perceptions of outreach. Before beginning the survey, participants were asked if they read the consent form, which was located as an attachment to the recruitment email with the link to the survey. The second question asked if they would like to be contacted with the results of the survey and gave a space to enter their email. These questions were followed by three demographic questions that asked about the highest degree held, sector of employment (public vs. private) and grade levels taught. The
following six questions looked into the teacher’s use of various outreach situations: a scientific exhibit at a museum; university or other outside laboratory; science fair, science Olympics or a similar event; science centre or planetarium; scientist-in-the-classroom; and professional development with scientists. The final seven questions inquired into perceptions about benefits, barriers, and outreach access. Space was provided for the participants to enter their comments.

3.1.3.3 Interviews

The qualitative phase of research was carried out sequentially, where appropriate participants (both teachers and outreach providers) for interviews were established using data from the survey and contacted via email. This sequential approach to the mixed methodology provided an important advantage (Johnson & Christensen, 2008; Onwuegbuzie & Johnson, 2004; Onwuegbuzie, Johnson, & Collins, 2009). The criteria used for selection of interviewees included: 1) successful implementation of or participation in science outreach; 2) long-term participation in science outreach; and 3) a position of prominence or notoriety within the science outreach community. This email provided the participant with a review of the purpose of the study, and the interview consent form for their perusal (Appendix B). After confirmation of the interview place and time, the participant was provided with prepared questions (Appendix C – Interview Script) as a starting point to reflect upon and develop dialogue. Qualitative semi-structured allow for a variety of perspectives to be heard, and open-ended questions to be asked in a way that allowed for follow up questions and problem questions. Further, due to technology, it was possible to interview people in various geographical locations. Interviews were conducted both in person, and over the phone using both a cell-phone and the computer program Skype. The length of the interview varied depending on how much information each participant offered.
The interviews were conducted over the course of February and March, 2012. In total, seven participants were interviewed during five one-on-one interviews, and one interview included two participants. Participants were deliberately asked similar questions to those used in the survey to ensure a cohesive research effort (Yin, 2006).

3.1.4 Data Analysis

Raw survey data collected by SurveyMonkey were exported to an Excel workbook. A worksheet was created for each question, where the data could be totalled and graphs created. Pie graphs were used to represent the overall data for each survey questions (Figures 3 to 10). A descriptive frequency chart was used to represent and compare all outreach practices for questions four to eight (Figure 11).

To further the analysis, the interviews were transcribed into Word documents. These transcriptions were read and important themes and topics were identified. It involved searching for expressions that responded to the object of the study by examining, categorizing, testing assertions for reliability and recombining evidence from the different interview transcripts with regard to description and interpretation of the emergent themes (Miles & Huberman, 1994; Yin, 2006). Analysis of interview data sets involved comparing within and across the sets to further clarify and interpret the emergent themes. I reviewed the interview transcripts back and forth respectively (Dahlberg & Drew, 1997) as I searched for emergent themes that cut across interview data sets. Interview passages with original wording that could enrich the study by providing more insight were identified. Finally, a comparison between results of the survey was made with the information gathered in interviews to check for corresponding or differing trends.
3.1.5 Reliability

In this study, the question of reliability regarding the interviews dealt with the consistency of the researcher’s interactive style, data recording, data analysis, and interpretation of participant meaning from the data. Data collection strategies used in an attempt to maximize the reliability of interviews included verbatim accounts, mechanically recorded data, and participant review. Member checking was conducted by informally testing interpretations and conclusions with members of the teaching and scientific community (Lincoln & Guba, 1985).

3.1.6 Validity

Validity refers to the degree to which the explanations of phenomena match the realities of the real world. The construct validity is grounded in teachers’ and scientists’ notions of science outreach as they experienced it. In this case the internal validity of this mixed methods study depends upon the degree to which the interpretations and concepts have mutual meanings between the participants and the researcher including such points as the participants’ language and the subjectivity of the researcher. Since the researcher is a teacher and also a member of the graduate student population at the University of British Columbia, from where many outreach scientist volunteers came, and also involved in the activities described by some of the participants, the mutual meaning and language were shared. The subjectivity of the researcher was constantly considered and self-monitored.

3.1.7 Ethical Considerations

To ensure my study followed appropriate ethical guidelines, I used individual committee members’ feedback and successfully applied to the University of British Columbia Behavioural
Ethics Review (BREB) Board for approval. In accordance with BREB procedures all participants received a “Consent to Participate” letter outlining the principal investigator(s), the conditions for participating and withdrawal from the study. To ensure anonymity and to maintain privacy and confidentiality, pseudonyms were used for all participants.

An e-mail inviting teachers and outreach providers to participate in the survey was sent to all members of the various listserv used for recruiting purposes. The email contained a link to the online survey and the letter of consent. The Study Proposal information e-mail contained a contact email and phone number so prospective respondents could request additional information about the study. The online questionnaire was installed on the Department’s secure server located in the Faculty of Education. During data collection, data were retained on the secure server: http://m1.cust.educ.ubc.ca. All responses were confidential and anonymous and IP addresses were not collected. All data were stored on a password-protected computer and documents stored in a locked filing cabinet.

Potential interview candidates were emailed with details of the study and invited to participate. A letter of consent was attached. In some cases I knew the participants personally through my own work in science outreach, and in other cases a contact was used to introduce me as I felt this would provide legitimacy to the study and encourage a sense of trustworthiness. All interviewees were emailed a copy of the prepared questions (Appendix C – Interview script), however, I allowed the participants to determine the specific direction of any conversation. Generally interviews began with the participants’ background in science outreach. More complex and in-depth questions were saved for the later portion of the interviews, once a good rapport had been established.
3.1.8 Design Limitations

There were certain limitations with regard to the study design and interpretation. One of the major limitations of this study is the lack of generalizability of the results to all teachers and scientists. Given the many factors that make a community unique, one community’s concerns or needs might be different from those in other geographical locations or student populations.

As in all interview situations, the biases of the interviewer may influence the data. As I had been involved in many outreach programs, and as such may have had personal biases. I may have asked leading, biased questions to support a particular point of view, or the interpretations may have been inaccurate. By being aware of the situation, I took precautions to minimize this situation, such as having my supervisor review the interview script and refraining from any displays of emotions during interviews.

3.1 Summary

The findings from the interview analysis were combined with the survey results to answer the research questions. These findings are presented and discussed in Chapter 4. In addition, the quantitative and qualitative data findings were used to generate recommendations for teachers and outreach providers on strategies that could be put into place to better utilize outreach opportunities.
Chapter 4: Data Analysis

In this chapter I present the analysis of the data collected from the survey questionnaire, and the six interviews. First, I present the survey data to establish the basic demographics of participants, the trends in outreach practices currently and for the past five years, and finally the attitudes and beliefs towards outreach in general. Secondly, I present the findings from my analysis of the interviews to provide a more in-depth look at the experiences of various stakeholders in science outreach. The quantitative and qualitative findings are examined together and discussed in more detail in Chapter 5.

4.1 Survey Questionnaire

The survey data were collected using SurveyMonkey. Each question had four or five choices. Depending on the question, participants could select one response or check off all responses they felt applied. Each question was analyzed in terms of the number of participants as a percent per choice and represented on a pie chart. This allowed for an initial visual analysis in response to research question one and two. The overall raw data were exported into an Excel (Microsoft 2011) workbook, and a worksheet was created for each survey question. Excel was also used for the construction of graphs and charts.

4.1.1 Demographic Information

In the survey-questionnaire participants were first asked about their post-secondary educational background and the grade level and system within which they teach. This demographic information was used to obtain a general sense of the participants as the Situated Cognition framework states that understanding cannot be separated from the context (Lave &
This information also allowed me to identify where there is the greatest need for science outreach. Further, it allowed me to identify areas where more research may be needed. For example, more participants at the elementary level would be needed to generalize these findings to all teachers.

Out of the 152 people who answered the survey, the majority of 144 or 95% had a science B.Sc. degree or higher, believed to be due to the listserv used to contact participants. Relatively few participants had a degree in math (6 participants or 4%), engineering (five participants or 3%) or computer science (one participant or <1%) (Figure 5).

Some participants used the comment field to specify other degrees in science such as a Master of Science in such fields as biology or technology. Further, some participants specified their educational credentials such as a Bachelor of Education (B.Ed.), a Masters of Arts in Education (M.A.) and Masters of Education (M.Ed.).

Of the 152 survey participants, 124 or 82% indicated they teach within the public school system and 28 or 18% indicated that they teach at a private or independent school (Figure 6).
For the purpose of this study, high school refers to grades 8-12. Elementary refers to both the primary grades of K-3 and intermediate grades of 4-7. As seen in Figure 7, most participants indicated that they teach at the high school level, both grades 8 to 10 (43 participants or 28%) and 11 to 12 (81 participants or 53%). Relatively few participants indicated that they teach at the elementary level: grades K to 2 (two participants or 1%); grades 3 to 5 (four participants or 3%); grades 6 to 7 (11 participants or 7%). It is hypothesized that this is due to the fact that professional science teaching organizations were primarily used to recruit participants for this survey. Secondary teachers are more likely to be a member and subscribe to the listserv given that they specialize in one or two subjects of instruction, compared to elementary teachers who generally teach multiple subjects.
4.1.2 Science Outreach Practices

Participants were questioned regarding their current and past outreach practices, including trips to outside sites such as university labs and science centers/planetariums, Science Fairs/Science Olympics, and collaboration with scientists, both in the classroom or participation in professional development. The intention was first to understand what outreach opportunities are being utilized by participants, both in the current school year and in past years. Secondly, these findings could then be used to interpret and understand the outreach practices and serve as a reference point for the interviews.

Teachers participating in the survey were first asked about their use of fieldtrips to outside laboratories such to university or college campuses. Almost half of the 147 participants (70 participants - 48%) responded that they had not engaged in this practice. Results indicated that 19 participants or 13% had been on a fieldtrip in the current year, with 21 or 14% indicating that they had not done this, but would like to do so in the remainder of the school year. A few participants indicated that they had been to a university laboratory in the past 2-3 years (17 or}

Figure 7: Levels taught by participants
12%) and past 4-5 years (20 or 14%). This indicates a steady rate of engagement in this outreach practice for the past five years (Figure 8).

![Pie chart showing participation in fieldtrips to a university or outside laboratory]

**Figure 8: Participation in fieldtrips to a university or outside laboratory**

Teachers were also questioned in the survey regarding their engagement in Science Fairs in any capacities; such as a judge or mentor to students. With 48 participants (33%) indicating that they had indeed done this during the school year, it was found that Science Fairs was the most popular outreach activity for the 2010-11 school year. This was a marked increase in comparison to past years with only 16 participants or 11% indicating they had participated in Science Fairs in the past 2-3 school years, and 29 or 20% indicating they had participated in the past 4-5 years (Figure 9).
When asked about fieldtrips to science centers, planetarium or similar facilities, participants indicated that 30 or 20% had done so in the 2010-11 year. This was similar to past years, with 22 participants or 15% indicating they had done so in the past 2-3 years, and 21 or 14% indicating they had done so in the past 4-5 years. Very few participants (21 or 14%) indicated that they had not done so but would still like to do it this year (Figure 10).
Survey participants indicated a growing positive trend in the use of the scientists-in-the-classroom outreach model, with 43 or 29% of participants having engaged in this outreach practice. This is a marked increase from past years, with 20 or 14% in the past 2-3 years and 17 or 12% in the past 4-5 years indicating they had done so. 67 or 46% of participants indicated that they had not had a scientist, or other STEM professional, come into the classroom (Figure 11).

Figure 11: Use of outreach – scientist-in-the-classroom model

Lastly, participants were asked if they had engaged in professional development with scientists. This option showed the greatest increase in recent years with a third of participants (49 or 33%) indicating they had done so in the past school year (Figure 12). This was an increase from the past 2-3 years at 22 or 15% and from the past 4-5 years where 17 or 12% indicated they had engaged in Professional Development (PD) with scientists. Professional development refers to anything done by teachers that help to contribute to their own learning throughout their career. Such activities could include individual collaborations, workshops or conferences. Oftentimes, a department or a school as a whole engages in PD during a number of days set aside for this purpose. 59 or 40% of participants responded that they had not done any PD with scientists (Figure 12).
When outreach practices were visualized as a frequency chart (Figure 13), it can be seen that the most popular outreach activity for the current year is Science Fairs. Interestingly, this was indicated to be the least popular activity in the past 2-3 years but once again, the most popular activity in the past 4-5 years. Frequency of fieldtrips to an outside laboratory remains steady, and the least employed outreach activity, while fieldtrips to a science center or planetarium were the second least employed outreach activity for the current year, despite a small increase from past years. It is hypothesized that this could be due to access, especially for remote locations, and costs associated with transport. However, this will be discussed further in later sections.

It is interesting to note a sharp increase in participation in Professional Development with scientists in the 2010-11 school year and an increasing trend overall. These data indicate a strong interest in the use of PD in outreach activities. This sharp increase in participation was also noted for Science Fairs, which was shown to be the most utilized activity in the 2010-11 year, as well as scientists-in-the-classroom.
4.1.3 Perceived Benefits and Barriers of Science Outreach

In the final set of survey questions, participants were asked to comment on benefits, both actual and perceived, as well as barriers to outreach. In the Situated Cognition framework, school culture and people affect one’s effective performance (Lave & Wenger, 1991). Therefore, it was felt that gaining an understanding of the beliefs and perceptions around science outreach was an important part of the research study. When participants were asked, who they believed currently benefits most from science outreach, 46% or 56 participants stated that everyone benefits equally and 39% or 56 participants stated that students were the main beneficiaries of science outreach.

Figure 13: Descriptive frequency chart for outreach practices of science teachers
Very few participants indicated that teachers (13%), parents or the community (1%), or scientists (1%) are the main beneficiary (Figure 14).

![Pie chart showing stakeholder benefits](chart.png)

**Figure 14:** Stakeholders who currently benefit most from science outreach

This result is in contrast to who the participants feel should benefit from outreach. Participants were given the choice of four various stakeholders and asked to select all who they felt should benefit. Overwhelmingly, with 92% or 131 of the total 143 participants selection (Figure 15), it was indicated that students should be the main beneficiaries of outreach. This strongly indicates that scientists and teachers plan and implement outreach to benefit students. However, this is not consistent with the previous answer that all participants currently benefit equally, nor with the indicated trend of increased use of science outreach for professional development. Very few participants (10% of the respondents) indicated that scientists should benefit from outreach although the literature suggests strong benefits to scientists, and the community as a whole do benefit from this practice (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005; Vitale, Romance, & Dolan, 2006). One participant, assigned the pseudonym Luke, used the space on this question to comment: “Theoretically everyone should. If the person doing the outreach isn't quite up to the task then a benefit becomes a negative. If this is done correctly,
with a person who's appropriately enthusiastic and engaged, it should be of great benefit to all concerned” (Luke, Teacher, January 2012). This indicates an important point in regards to scientists who engage in outreach: the scientist should implement outreach in a passionate, meaningful way that is helpful to the teacher, and interesting and understandable for the students. This suggests that scientists should not be coerced into participating in outreach, but rather encouraged to do something that they are passionate about. Secondly, it suggests that scientists needs to be trained on how to effectively communicate and pitch the material to the right level as well as work with the teacher to ensure that the lesson is helpful.

**Figure 15:** Stakeholders who should benefit the most from science outreach

Participants were also questioned regarding what prevents them from participating in outreach and then permitted to tick off the various factors. Overwhelmingly, 72% or 103 participants, indicated that time is the main preventative factor (Figure 16). Some participants used the comment section to specify why they feel time is a factor, with one participant saying that there are “‘teach to the test’ constraints” and another stating “time to fit into the school days and cover the curriculum” (Elizabeth, Teacher, January 2012).
The second most important factor preventing outreach indicated by participants was the lack of access at 39% or 56 participants. The remaining three factors (remote location, lack of encouragement, and difficulties tying in to the curriculum) were indicated to be similarly factors at 20% or 29 participants, 20% or 28 participants and 19% or 27 participants respectively (Figure 16). It is also interesting to note that 19 participants chose to enter comments that indicated that money (also referred to as cost, funding or finances) was an issue. Mostly this was a general comment, however, some participants were specific, citing “funding to pay of subs and transportation” (David, Teacher, January 2012). This indicates that these teachers viewed outreach for this question particularly in terms of fieldtrips, as opposed to scientists coming into the classroom.

Finally, it is interesting to note that two participants, assigned the pseudonyms Mike and Tony, entered comments for this question of the survey, that indicate that science outreach is seen in a negative light. One participant, Mike, indicated that science outreach is not encouraged at their school, and also stated “students derive little benefits from it” (Mike, Teacher, January 2012). Another participant, Tony, who indicated three factors (time, lack of access, & remoteness) also commented:

First, this is all predicated on the scientist coming to the classroom. If you have time for that, with all else you're otherwise normally expected to be doing, then something's wrong. We have a math/science/technology program and the science national honor society brings in to speak to the students and there's an open invitation for anyone to attend. (Tony, Teacher, January 2012)
This is of note for various reasons. Firstly, this participant perceives outreach to be scientists coming into the classroom, rather than primarily fieldtrips which is different to those participants indicated above. Secondly, it indicates the attitude that science outreach is for teachers to supplement the curriculum perhaps as enrichment, rather than as a way to deliver the set curriculum and inspire students who might not naturally choose to enter the sciences.

Figure 16: Barriers preventing teachers from engaging in science outreach

Participants were asked to express their opinion as to why scientists should participate in science outreach by asking to choose all the reasons that they felt applied (Figure 17). The five statements that were provided were created after a careful reading of the literature and personal experience, as it was felt these statements best described reasons for scientists to participate in outreach.
Figure 17: Reasons for scientists to participate in science outreach

The results were consistent to previous questions, where it was indicated that students should be the main beneficiaries to outreach, as 75% or 107 participants felt that scientists should participate to be role models and inspire students (Figure 17). Again, consistent with previous questions in the survey, it was felt that teachers are an important beneficiary of outreach, with 49% or 70 participants indicating that scientists should participate to both inspire teachers and refresh their own knowledge.

When asked who does (Figure 14) and who should benefit from science outreach (Figure 15), parents and the community was the least indicated choice. However, 59% or 85 participants (the second most popular answer) felt that scientists should participate in outreach to raise the level of scientific literacy of the general public. This suggests that scientific literacy is felt to be an important issue for students, rather than the community as a whole. Moreover, 29% or 42 participants indicated that they felt scientists should participate in outreach to give back to the community that funds their research.
The least number of participants with 20% or 29 participants stated that scientists should participate because of the benefits of outreach to themselves; for example, enhanced communication skills. In fact, once again concerns over the ability of scientists to communicate were expressed in the comments section of the survey question:

If a scientists or engineer is using this opportunity to improve their communication skills they’re a detriment not a positive in this effort. This is not the place to have people come out to practice, that should have occurred when they were post-docs or otherwise in a less impressionable environment. (Lucy, Teacher. January 2012)

Therefore, scientists as having the power to influence students’ perceptions are generally seen in a positive light. However, it is indicated that if the scientist is not properly trained or seen in a “positive” light that the opposite can actually occur. This corroborates the personal viewpoint formed from previous experience. There need for a good relationship between the teacher and scientists where both help and support each other to ensure a good experience for all.

Participants were asked to comment on why they might want to learn more about science outreach opportunities. Again, set statements choices were provided that were formulated from both the literature and personal experience (Figure 18). Participants could choose any or all statements they felt applied.
The data revealed that eleven percent (11%) or 16 participants indicated that they might want to learn more about science outreach opportunities because they did not have a strong background in science. Given that the majority of participants taught grade 11 & 12 or university, this sentiment is not surprising, as it is assumed they would most likely feel comfortable with the material. It is felt this would be more of an issue for teachers in elementary schools who are generalists and might not have a strong background in science.

Participants were evenly split among the remaining choices, with 61% or 86 participants selecting to increase student motivation and interest in science. In addition, 57% or 80 participants indicated it would be a great experience for their students, and they want to learn more about available opportunities, and 36% or 50 participants want a role model or career ideas for students. All three of these answers indicate that participants regard outreach as an opportunity to ensure primary benefits to the students involved. Of the participants, almost half

Figure 18: Motivation for learning more about science outreach
at 47% or 66 participants regarded outreach as a way to access equipment or information, such as cutting edge research, that they might not have access to, but they believe students would find interesting. This question indicates that there are various motivations for pursuing science outreach, and various needs that could be met this way, suggesting that one model of outreach would not necessarily apply for all situations.

The last question in the survey asked participants if it would be helpful to have one website where all (or most) outreach opportunities available to the students in a particular region could be accessed. The results are displayed in Figure 19.

Figure 19: The importance of a website that provides access to current outreach opportunities

An overwhelming 73% or 103 participants indicated that yes, they felt this would be helpful as it would be easier to find and organize outreach activities. A further 4% or 6 participants indicated that they know of sites, but that they are not useful or up-to-date (Figure 19). This indicates that very few people know where to go to access or look for outreach opportunities, which is supported by the fact that only 9% or 13 participants indicated that they felt finding activities is
not a problem. This supports data collected from question 14 of the survey (Figure 18) that state
time is the biggest barrier in a place for outreach as it can be time consuming to seek out and
organize outreach activities. The data from question 14 of the survey further confirm this finding
(Figure 19), only 14% or 19 participants felt that there were other barriers in place, in addition to
finding outreach opportunities, that would prevent them from taking advantage of those
opportunities (Figure 18).

4.1.4 Summary

In recent years, a trend has emerged among science teachers to participate in science
outreach activities, especially as part of their professional development or outreach opportunities,
such as the scientists-in-the-school outreach model (Laursen, Liston, Thiry, & Graf, 2007a; J. M.
Pegg, Schmoock, & Gummer, 2010). Both scientists and teachers are seen to be motivated to
engage in outreach primarily for the benefit of their students. Participants believe that currently
everyone does benefit equally, with students benefiting the most. However, there is the
perception among some teachers and outreach providers that students should be the main
beneficiaries of outreach rather than looking to ensure that all stakeholders benefit equally.
Despite the use of scientists in teachers’ professional development, few acknowledge or see
benefits for the scientists themselves from engaging in science outreach. It is also recognized that
teachers benefit from an increased access to knowledge and equipment, they might not otherwise
be able to access, through science outreach or collaboration with scientists. It is believed that
scientists should engage in outreach to provide motivation, access to role models, and generally
to raise the level of scientific literacy of students and teachers. Moreover, some participants
expressed concern that outreach can actually do the opposite of what it intends if the scientists do
not provide a positive experience, due to lack of enthusiasm or an inability to communicate at the right level to students.

Although teachers’ motivation to participate in outreach varies, lack of time for teachers is the major barrier to implementation of outreach especially in regards to finding opportunities. It is believed that one up-to-date website would be helpful in accessing opportunities. Cost, lack of access and being in a remote location are also cited as barriers to utilizing outreach, indicating the need to provide various opportunities in both rural and urban centers that are at little or no cost to the schools or students. This suggest that it is more effective to bring one or two scientists to a community, or alternatively recruit scientists from the community itself, rather than take students outside of the classroom to engage in outreach activities.

4.2 Interviews

To provide a more in-depth look into factors affecting science outreach, I conducted six interviews with various outreach providers and teachers. Five interviews were of scientists and outreach providers, including: Jennifer, Greg, Mark, Kate, Anne and Jane (pseudonyms are used for purposes of privacy). Jennifer is a trained scientist, and as the founder of a national Canadian science outreach provider, she now spends her time running this organization. Greg is a retired physics professor from the University of Western Ontario. Mark is a working scientist in British Columbia and is involved in various outreach initiatives for both teachers and students. Kate is a scientist at the University of British Columbia and has been involved in various science outreach initiatives, most prominently in Science Fairs at the national level. Anne and Jane work together at a large science research center that has many roles, one of which is to provide science outreach. Anne has been an administrator in science outreach for a long time within this
organization. Jane holds a research appointment with a large research university, and is on contract to this facility having recently moved from another organization where she was also in charge of science outreach. Given their different backgrounds and roles within the same organization, Anne and Jane were interviewed together to offer insight into these different but overlapping positions. One interview was conducted with John, a classroom teacher for over twenty years, who currently instructs future teachers.

These interviews provided extensive data that was analyzed to extend the survey findings, as well as substantiate the literature. My analysis of these data is discussed in the following sections. I have organized my presentation of data under the headings of: benefits, barriers and the recommendations for science outreach. These headings come from themes that emerged during the course of the interviews.

4.2.1 Perceived Benefits of Science Outreach

At the beginning of each of the six interviews, I asked the participant to describe their overall experiences in science outreach. In most cases this involved what personally motivated them to first get involved, and why they stayed involved in science outreach over the years. Some of the participants cited benefits to the students, others cited feedback from teachers as to the benefits they have obtained, while others talked about benefits they themselves experienced. Usually a combination of the three was given, as well as reasons for the necessity for the overall promotion of the sciences.
4.2.1.1 Benefits to the scientists

Two of the interview participants, both a scientist and a teacher, became involved in science outreach for personal reasons, such as their own children. This validates the finding that scientists become interested in science education at the K-12 level when their own children are in school, with the aim of enriching their own children’s education (Vitale, Romance, & Dolan, 2006). It is interesting to note that though this was the initial reason for beginning science outreach, various other factors kept them involved over the past ten years.

When asked what keeps them involved in outreach, participants often cited various anecdotal evidence based on their experiences. Greg stated that, “I had the privilege of getting to know some remarkable young people over the years so that’s what kept me going personally” (Greg, Scientist, February 8, 2012). Not only is there personal satisfaction to the scientist but, as states, “in the case of post-graduate volunteers such as Masters and PhD students, there is considerable benefit to the host institution from this student experience” (Jennifer, Outreach Organization Founder, February 10, 2012). It seems that various organizations, like universities, businesses and corporations are seeing benefits to having employees participate in outreach. This is corroborated by Jane who states:

It’s amazing how many organizations, when they hear about our program really want to get their employees involved because they learned to appreciate the importance of their employees having those skills and having that experience and also the advantage of them sharing who they are and what they do, so they can recruit the future generation into their organization, into their job line. (Jane, Administrator, February 14, 2012)
Organizations are seeing a direct benefit in terms of skills their employees gain, but also long-term benefits in terms of future potential employees. Other benefits are indirect and come under the heading of research funding. One participant described applying recently for a Canadian Institute of Health Research (CIHR) grant, and stated:

In CIHS grant there is a tick off box that you have to read and tick off before you can submit which basically says that having the ability to apply for grants means that you are also going to give your time to sit on peer review committee to work with youth in science fairs such as SignAp, so there’s an expectation that you are not just taking money in, you’re giving back to society. (Kate, Scientist, February 21, 2012)

Data suggest there is the understanding by scientists that it is important to promote science in the wider community because of the direct and indirect benefits to themselves.

4.2.1.2 Benefits to society

By participating in science outreach, scientists are able to inspire a future generation to enter the sciences. This supports and promotes future research within Canada, as stated by one participant, John: “If our society wants to continue to be a leader in science in research, and I believe we are, then it has to start with the classroom” (John, University Instructor, March 1 2012). It is not enough to encourage current undergraduate students to enter research, but rather this is a process that must begin as early as possible. Another participant echoed this sentiment stating that: “STEM often comes down to “that’s a university thing and a senior high school
thing. From my perspective, the outreach needs to start with kindergarten teachers” (Greg, Scientist, February 8, 2012). Further, not only is it important to encourage future researchers, but it is important to make science accessible to everyone: “if we are going to build a society that embraces science learning we need to have them exposed to positive experiences throughout their life” (John, University Instructor, March 1, 2012). Situated cognition framework proposes that interaction with the world in meaningful situations brings one towards a specified intention (Lave & Wenger, 1991). Therefore, providing these opportunities for students and promoting a positive attitude towards science will have long lasting effects. Mark’s attitude, consistent with that of other scientists interviewed, is that: “A scientist is not just three or four letters after your name, it’s a certain way of thinking” (Mark, Scientist, February 28, 2012). The benefits to society of science outreach are not immediate, but rather they are long-term. These benefits are two-fold. Firstly, it is important for society as a whole to embrace science learning and attain a basic level of understanding. Secondly, science can benefit by continuing to get people to enter the STEM fields and continue to conduct science research at an advanced level. Anne and Jane refer to something that they term the “science gap”, where students are not going on to study science at the post-secondary level.

Kids are unaware of all the awesome science jobs that are out there. They think science is working in a lab, being a doctor, testing blood and specimens and they think that the only location for them to have these jobs is in the US or elsewhere in the world. They don’t exist here in Canada. (Anne, Scientist, February 14, 2012)
Findings show that science outreach providers and teachers have a common goal: to promote scientific literacy and motivate students to enter science which will have long-term benefits for society as a whole. However, this is a long-term investment that needs to start as early as possible in the classroom.

4.2.1.2 Benefits to teachers

Participants acknowledge various benefits to teachers for engaging in science outreach. The Situated Cognition framework discusses knowledge as an action or verb, which is co-determined between the agent (the teacher) and the environment (scientific community). Therefore, the more teachers participate within the scientific community of practice, the more their knowledge would evolve (Lave & Wenger, 1991). Mark states that one benefit is that “teachers could get ‘real-world’ context to some curriculum questions that they otherwise don’t have any resources for: ex. relativity, electromagnetism, circular motion”. Science outreach could allow teachers to show how theory learnt in the classroom could be useful in contexts of the real world. However, it was acknowledged that outreach was most useful when it covered topics already found within the curriculum. It was important to make the job of teachers easier and the best way to do this was to provide something material that teachers could continue to use.

They [outreach providers] not only reach out to the students, but they also reach out to the teachers and they give a combined set for when they leave. They don’t just leave with the experience, the teachers have training and understanding and
a lesson in hand that they can do themselves. (John, University instructor, March 1, 2012)

Various benefits exist for teachers. However according to teachers, the biggest benefit to them comes from having tangible resources that can be incorporated into their teaching practices relevant to the prescribed curriculum.

4.2.1.4 Benefits to students

In both the survey and interviews participants were asked who does and who should benefit most from science outreach. In both cases it was strongly felt that of the various stakeholders, students are and should be the main beneficiary. Data from the survey revealed that 39% of participants indicated that students are currently the main beneficiaries, and 92% felt they should be (Figures 12 & 13). The main advantage given in interviews was that students: “Get the experience of talking to some of the world’s top scientists and that just blows them away.” Not all students have access to or understand the role that scientists play. Without such an understanding, these students are without rich contexts as specified in the Situated Cognition framework (Lave & Wenger, 1991). Without this context, students’ learning will not reflect that of real life and the learning processes that scientists undertake in their work. The opportunity to talk and interact with professionals is one that many participants report is appreciated by the students. Greg found that these encounters: “definitely changes attitudes around the possibilities of careers in those fields” (Greg, Scientist, February 8 2012). This is consistent with the findings in the literature (Let's Talk Science, 2007). According to (2006) teachers are often motivated to collaborate with scientists because of the perceived benefits to their students, rather by any
advantages they might experience directly. This proved to be the case with many advantages listed that apply to most, if not all, of the various science outreach activities.

One participant, involved in Science Fairs at the national level, listed in what universities and programs past winners are currently enrolled. He states that: “when you take kids like that you open their eyes and open doors for them” (John, University Instructor, March 1 2012). When the interviewee was asked, by my inquiring whether these students would have been successful without science outreach, John countered that the student believed they would not have been successful at the current academic level.

Science outreach that involves events where students gather together, such as Science Olympics or Science Fairs, also allows students to benefit from the gathering of students interested in science. The Situated Cognition framework states that social interactions and relationships are important for learning and knowing (Lave & Wenger, 1991). John states that “they get to talk to some of the world’s top science students” (John, University Instructor, March 1, 2012). Just as important as meeting scientists, the interactions between the students themselves are also important. Students from different areas, who share the same passion and interest for science can meet and make connections.

4.2.2 Perceived Barriers to Implementation of Science Outreach

During the interviews, various perceived barriers to science outreach were listed. I have organized these into five categories: cost, time comfort with science, engagement and access. These categories were used to organize and illustrate emergent themes that arose from the data.
4.2.2.1 Cost

Participants referenced the expense of organizing and producing the outreach activity itself, and also cited the costs associated with participation in these opportunities. For example, Greg talked about the costs involved in providing outreach opportunities: “If you are going to invite a hundred judges to give up a day of their time you have to feed them, so there are real costs” (Greg, Scientist, February 8, 2012). In addition to creating outreach opportunities, there are associated costs that pose barriers. Teachers who leave school to take advantage of outreach opportunities create the need for supply teachers and this cost is increasing becoming a barrier to their participation. John states: “It is getting very tough to get supply teachers because we don’t have any money” (John, University Instructor, March 1, 2012). These problems become even more of an issue due to the large geographic area that comprises Canada. For example, when describing science fairs at the national level, Greg responded that: “you are looking at $800 to $1000 per head for an airfare” (Greg, Scientist, February 8, 2012).

Costs are also a barrier for outreach opportunities in which teachers would benefit; for example, professional development. One participant, Mark, states that “In a lot of cases the school boards and Ministry are hindering, for example the decision not to fund teacher professional development workshops, or allow teachers to attend these workshops” (Mark, Scientist, February 28, 2012). Therefore, cost is a barrier to outreach activities and decided at a level where teachers have no input or alternatives. It is not only the cost in terms of direct monetary expenses that was referenced. When questioned regarding barriers to outreach, Jennifer stated: “One is funding, it is resources to build that informal system that works in partnership with the formal system” (Jennifer, Outreach Organization Founder, February 10, 2012). The need to create connections that would allow access to resources was a reoccurring theme in
interviews. One participant, talked about the need to change the way things are done, at a high level:

To really make progress, informal science promotion agency’s like TRIUMF\(^1\) and UBC have to be more strongly coupled with the system in order for this to work properly. It would work a lot better if we were working with the school boards and the ministry than in a lot of cases working against them. (Mark, Scientist, February 28, 2012)

To provide outreach opportunities, money is a barrier. However, even when opportunities are available to teachers and students at no cost, indirect costs can provide a barrier to participation.

\subsection*{4.2.2.2 Time}

The data suggest that time is a barrier to outreach in three ways: curriculum, scientists and timetabling. It was clear that those interviewed were familiar with the many responsibilities and demands placed on teachers today, and the limited time teachers have to teach the curriculum. Therefore, some participants felt that it would not be possible to conduct science outreach on any topic not found within the curriculum. As John states: “You can’t do additional things because you are constrained by the need to get through the material and you you’ve only got a fairly limited time to do it” (John, University Instructor, March 1, 2012). Though there are many interesting topics that could grab the interest of students, it would mean that teachers

\footnote{TRIUMF is a Canadian national laboratory for nuclear and particle physics research and related sciences. It is located on the campus of the University of British Columbia (UBC) in Vancouver. It is owned and operated as a joint venture by a consortium of universities.}
would not be able to cover the mandated topics and force them to exclude something else from their teaching. Related to this, is the fact that scientists are busy with their own work. Anne and Jane reference time and link it to curriculum concerns, with Anne stating: “I think it’s also timing, so if you are getting people who are experts, they can’t always show up Tuesdays at 10:00am or just the perfect time in the curriculum for that topic to be discussed” (Anne, Scientist, February 14, 2012). Finally, the timing of schools also posed unique problems to certain outreach activities. Greg stated that, “the practice of semestersing in schools makes it more challenging for teachers to put on Science Fairs” (Greg, Scientist, February 8, 2012). When courses run for one semester instead of over the course of the entire year, this makes it difficult to participate in prolonged activities such as Science Fairs. Teachers are very busy, and they also are confined by the school timetable and the curriculum they must cover. Scientists are also very busy. Therefore, finding a time that suits teachers, scientists, and the specific topic being taught, are all potential barriers in science outreach related to time.

4.2.2.3 Comfort with science

For teachers to innovate and appreciate outreach opportunities, it is important for them to either understand the science that is involved, or to see how the activity will help them gain this understanding. For the purpose of this study, the term “scientific community” refers to a group of people who share common perspectives, and engage in the common pursuit and dissemination of scientific knowledge. Teachers must feel that they are part of the scientific community, and have access to all that this community membership entails, to become part of a community of learners. This membership is known as legitimate peripheral participation in the Situated Cognition framework (Lave & Wenger, 1991). For some outreach activities to be initiated by the school,
teachers must have this science knowledge. However, according to one participant, Greg, “the number of people who are trained physicists going into high school teaching is way down, you don’t have the critical mass to do extra stuff” (Greg, Scientist, February 8, 2012). Outreach activities would be classified under the heading of “this extra stuff”.

A lack of a solid foundation and training in the sciences means that these teachers might not appreciate the opportunities that are available to them or their students. One outreach provider, Mark, stated that: “what we are doing is advanced science and the number of chemistry teachers who can appreciate advanced science or have a degree or they can begin to understand it is very-very small” (Mark, Scientist, February 28, 2012). Resources created for outreach use must be simple as many teachers are not comfortable with the material and therefore would not utilize it otherwise. Other participants feel that comfort with science might lead to issues of control:

The big thing I think is control and the teacher that fits the curriculum… your experts aren’t experts in the curriculum. So you can’t expect the experts coming in to be able to say this is where I fit in in the curriculum, and the teachers often don’t know enough about the subject, which is why they are bringing someone in to talk about it, to say how does this fit in with this curriculum line. So there is a gap there. (Anne, Scientist, February 14, 2012)

Though both stakeholders, the outreach provider and the teacher, have the potential to benefit from the other’s expertise; this can also pose problems.
4.2.2.4 Engagement

Engaging teachers, especially as it recognized that they have many demands on their time, poses a barrier to the utilization of outreach. Outreach is not something that can, or should be forced upon teachers. In the words of another participant:

For the most part you are dealing with people who are already in a sense motivated. For people who don’t care, there is nothing you can do, you can’t force them. If you are in a classroom you can get to do something because they have to but when you are doing outreach it’s an elective… (Mark, Scientist, February 28, 2012)

Therefore, it seems that for outreach providers, apathy is a barrier to outreach. Engagement can come about by appealing to teachers’ needs and offering them something they value but cannot provide, as Jennifer indicated when she stated, “the other part is the understanding of the value that together the partnership makes” (Jennifer, Outreach Provider Founder, February 20, 2012)

Many times a negative experience with a scientist or event can cause teachers and community members to disengage from future opportunities. For example, John gave the anecdote where one parent did not support the teacher’s effort to implement a science outreach as “30 years before she was humiliated, not embarrassed, humiliated by her classroom teacher in front of her class giving her presentation for the first time”. Teachers also talk about the importance how material is delivered, as lecturing to students is not an effective way to reach them. It is interesting to note that scientists recognize this, and Greg states: “the trouble with scientists is that is what we do; we lecture. So there is a slight disconnect there”. Anne and Jane
also recognize the need for scientists to be trained, with Anne stating “we run training sessions for scientists to be able to do that, to be able to go in and talk to a classroom of kids in a fun and interactive way”. Science outreach should involve a hands-on approach to learning where the material is delivered at the level for the students involved for maximum engagement. Anne and Jane stressed the importance of hands-on learning when they elaborate, and Jane states:

It’s one for thing for a scientist to go into a classroom and talk about what it is they do. It’s another case to go into the classroom and hand out things and get kids making stuff and touching stuff, and doing stuff and being fun and obviously the important thing is being interactive. Kids, if they touch and feel and play, they are not just listening to someone and they are going to learn better. (Jane, Administrator, February 14, 2012)

The Situated Cognition framework indicates that individuals learn through experiences (Lave & Wenger, 1991). John Dewey also theorized that experience is important in learning. For education to be most effective, subject matter must be presented in a way that allows for the students to connect new information to past experiences and understanding (Dewey, 1998). These findings suggest that outreach providers understand this and are aware of the need to train scientists on how to engage and deliver material at appropriate level. “Good” science outreach seeks to engage teachers by providing opportunities they cannot provide themselves, and linking the outreach to the curriculum. This leads to questions of access and how best to market and make science outreach accessible for teachers.
4.2.2.5 Access

While working in various outreach organizations, I was always surprised at the amount of time and effort these organizations spend trying to approach teachers. It was interesting to hear that many of the interviewees had the same experience, Mark stated:

I actually had to work hard to find teachers to do this and after a while I’m like why am I doing this? If you don’t want to come, I am not going to kill myself. So eventually we stopped advertising. If somebody asks me and says ‘hey are you still doing that - I am interested’, I will do it for them. (Mark, Scientist, February 28, 2012)

Despite their best efforts, organizations had trouble getting access to teachers who could benefit from what they were offering. When asked, Anne and Jane also reflected on the uptake of outreach opportunities.

I talk to teachers, when I’m traveling around the community and I talk to teachers about the program. I am shocked at how many have never heard of it. My first response is usually, are you a new teacher because if that’s the case we are missing something with that information not being carried down through teacher generations, and that’s not usually the case. Obviously it is sometimes. We don’t do a lot of promotion for our program anymore. We rely on word-of-mouth. We rely on those teachers that do it every year to do a little bit of sharing (Anne. Scientist, February 14, 2012)
This suggests that the best advertising and access to teachers is through teachers who are already involved in science outreach. Conversely, many teachers felt they did not know where to go to access opportunities being offered. Possible solutions involved a third party and the use of technology. The Internet and other communication technologies, as indicated by the Situated Cognition framework, affect learning. Therefore, it is important to understand these tools and how and membership and interaction within the scientific community can be encouraged through their use. One solution expressed by Mark was:

To run a central website so we know who everybody else is and what everybody else is doing. We could share things but without a central, third party to host this it’s not going to happen because nobody, none of these individual organizations has the resources to host for the whole. (Mark, Scientist, February 28, 2012)

For this to occur the cooperation of many organizations and financial support would need to be provided. Most likely this should come at the national level. For the purpose of this study national, in the context of the US refers to the federally controlled Department of Education, while for Canada, refers to a coordinated effort by provincial Ministry of Education. However, given the diversity found within Canadian communities, many caution a one-fits-all approach. Rather, a local approach is advocated, where a member of the community is drafted into service helping an organization establish a presence for outreach. Anne and Jane refer to this as empowerment:
One thing I have learned being a manager of people is the most important thing is to enable people and to give people a sense of responsibility and ownership, it’s the best way to accomplish something… empower the volunteers that currently exist to take a little bit more responsibility of the program (Jane, Administrator, February 14, 2012)

Data suggest the need for a third party mediator or outlet that can facilitate partnerships and opportunities between teachers and outreach providers. Solutions include the use of technology, such as a website that allows teachers access to up-to-date information or a member of the local community to act as a representative or champion.

4.3 Overall Summary

The analysis of the quantitative and qualitative data in this chapter explored the benefits, barriers, and various factors that teachers and outreach providers consider important to the implementation of outreach. The analysis also suggests important factors for planning and implementing science outreach. It was found that high school students, especially those in grades 11 and 12, are more likely to be beneficiaries of science outreach than their elementary counterparts in grades K to 7. Neither private nor public schools are more likely to engage in science outreach. Teachers who are comfortable with science, or have more extensive training or connections to the scientific community are also more likely to engage in science outreach. These data suggest that targets of science outreach should be students in elementary school. Those already involved in outreach, both scientists and teachers, should be utilized in the
recruitment and promotion of science outreach through word-of-mouth. Steps followed in planning and implementing outreach include appropriate training of outreach providers to ensure good attitude and delivery of the material. Hands-on, student-centred activities as opposed to lectures are important, and giving students real-life context, opportunities and uses of science is important for inspiring a lifelong interest in science as well as a great awareness and understanding. Barriers to science outreach included cost, time, access, engagement, comfort with science, and access. A model that incorporates the use of technology, a third-party facilitator (a local member of the community) would allow for better utilization of outreach opportunities. In the following chapter, I will amalgamate the factors and themes that emerged from the analysis of the survey and interviews and will discuss how they relate to one another and previous literature.
Chapter 5: Discussion

In this chapter, I will discuss the results that emerged from my analyses of the quantitative and qualitative data in this study. First, I will combine and compare the survey and interview results to help determine what factors various stakeholders perceive as both beneficial and barriers to implementing science outreach. I will also consider why these two stakeholders identified these factors as important. Second, I identify who is the likely beneficiary of science outreach and why. Finally, I will summarize the overall findings and propose strategies that could be implemented to harmonize the good intentions of the various parties to best utilize and implement science outreach.

5.1 Beneficiaries of Science Outreach

The Situated Cognition framework states that understanding cannot be separated from the context (Lave & Wenger, 1991), and therefore the educational backgrounds and contexts of work represented by the participants were first examined. Of the 152 survey participants, 124 or 82% indicated they teach within the public school system and 28 or 18% indicated that they teach at a private or independent school (Figure 4). Given the greater number of public schools, this indicates that this feature is not a factor in identifying likely participants of science outreach. However, the students’ grade level, and the teachers’ educational background and exposure to science, were both factors that influenced the likelihood of their involvement in science outreach. In the survey, most participants indicated that they teach at the high school level (Figure 3), both grades 8 to 10 (43 participants or 28%) and 11 to 12 (81 participants or 53%). Relatively few participants indicated that they taught at the elementary level: grades K to 2 (2 participants or 1%); grades 3 to 5 (4 participants or 3%); grades 6 to 7 (11 participants or 7%). It was
hypothesized that one reason was the fact that professional science teaching organizations were primarily used to recruit participants for this survey. Secondary teachers are more likely to be a member and subscribe to the listserv given that they specialize in one or two subjects of instruction, compared to elementary teachers who generally teach many subjects. As seen through the lens of the Situated Cognition framework, secondary teachers are more likely to be fully participating members of the scientific community and therefore find and act upon outreach opportunities. Data from the interviews corroborate the survey findings. For example, the attitude towards STEM is that: ”it’s a university thing and a senior high school thing” From my perspective, the outreach needs to start with kindergarten teachers” (Greg, Scientist, February 8, 2012) These findings support the literature that states only 17% of science outreach is done in a classroom and only 8% involves the community’s youth (Let's Talk Science, 2007) and that students who choose a career in science or mathematics, do so before the ninth grade (Bruce, Bruce, & Conrad, 1997). Lave and Wenger (1991) emphasize that novices begin learning by observing members of the community and then gradually moving from the periphery of the community to fully participating members.

The survey indicated that participants perceived students to be the main beneficiaries of science outreach (Figures 12&13). It was found that 61% of participants wanted to learn about outreach in order to increase student interest and motivation in science while 57% thought it would be a good experience for their students, and 36% wanted to provide a role model or career ideas for their students. From the interviews, various benefits to students were given, including: “changed attitudes around the possibilities of careers in those fields” (Kate, Scientist, February 21 2012). This allowed for an indirect benefit to society and businesses, as a future skilled STEM workforce would be created. This attitude is supported by both teachers and outreach providers
such as John who stated: “If we are going to build a society that embraces science learning we need to have them exposed to positive experiences throughout their life” (John, University Instructor, March 1, 2012). This supports findings in the literature that state classroom outreach activities are shown to qualitatively impact positively students’ interest in science and hence their eagerness to learning science, thus leading to an increased likelihood of pursuing a career in this field (Laursen, Liston, Thiry, & Graf, 2007b). Further, the data support research that shows that the aim is for an education system where children are exposed to high-quality science inquiry in each year of elementary and middle school supported by prepared science specialists (Alberts, 2009). This repeated exposure is an important characteristic for communities of practice as it takes time and sustained interaction to develop relationships (Lave & Wenger, 1991).

5.2 Strategies

5.2.1 Science Attitude and Ability

From the survey, it was apparent that some teachers believed that outreach could be used to provide access to equipment and information that the teacher did not have but would be of interest to students. A much smaller number stated they lacked a strong scientific background, and outreach would help to provide ideas and supplement lessons. Pegg & Gummer (2010) state that many teachers at the elementary and the secondary level have never been directly engaged in scientific research. This finding is compounded by the fact that according to evidence in the interviews “the number of people who are trained physicists going into high school teaching is way down” (Greg, Scientist, February 8 2012). Therefore, it is harder to organize outreach events from within a school as there are not enough trained people to support these efforts. A school
that has highly trained science teachers is more likely to feel comfortable with and take advantage of outreach opportunities.

The Situated Cognition framework presents learning the discourse of the community as key to becoming part of a community of learners (Lave & Wenger, 1991). Interviews gave rise to data that suggest both scientists and teachers believe that it is important for students to be trained to view the world and think in a scientific way. In the interview one outreach provider, stated that: “a scientist is not just three or four letters after your name, it’s a certain way of thinking” (Mark, Scientist, February 28, 2012). Science outreach would help facilitate this enculturation necessary for attainment of a scientific worldview and help to legitimize students and teachers’ ways of thinking and knowing (Lave & Wenger, 1991). A teacher, John, also felt the need to instruct students from a young age. He states: “If our society wants to continue to be a leader in science in research, and I believe we are, then it has to start with the classroom” (John, University Instructor, March 1 2012). This belief reflects findings from the literature, such as those from experts like Bruce Alberts, Editor-In-Chief of Science, who states that we must look to redefine science with the focus on gaining scientific habits of mind, as opposed to recall of facts (Alberts, 2009). Further, though science outreach can support teachers in their efforts for inquiry-based learning, it is felt that, for the most part, such changes will have to come from within the education system (Nature Neuroscience, 2009).

5.2.2 Delivery of Material

From the survey, it was clear that time constraints with 72% of participants agreeing, is the major barrier that prevents teachers from engaging in science outreach (Figure 14). Multiple sources in interviews agreed with this sentiment, stating that there is a large amount of course
material for teachers to cover. One interviewee, Greg, went further and stated, “you can’t do additional things because you are constrained by the need to get through the material and you you’ve only got a fairly limited time to do it” (Greg, Scientist, February 8 2012). Therefore the data suggest that science outreach should ideally help teachers deliver the curriculum and not add additional topics, as this would actually add to the teacher’s burden, as opposed to help them. This was reflected in the statement from another participant:

They [in reference to an unnamed science outreach provider] are a fabulous group because they not only reach out to the students, but they also reach out to the teachers and they give a combined set for when they leave. They don’t just leave with the experience, the teachers have training and understanding and a lesson in hand that they can do themselves. (John, University Instructor, March 1, 2012)

It is felt that a good science outreach organization, in addition to grabbing the interest of students, gives teachers the ability and material to deliver and elaborate upon a topic. Learning, as defined by the Situated Cognition framework, should be driven and best represented through realistic and complex problems that allow for learners to think and practice like experts in the field (Lave & Wenger, 1991). This was corroborated by Mark who stated that one benefit to teachers is that “science outreach allows them to give ‘real-world’ context to some curriculum questions that they otherwise don’t have any resources for: ex, relativity, electromagnetism, circular motion”. This confirms findings from the literature that state one role of the teacher is to provide opportunities to engage with happenings in the area being studied and to allow students
to explore “real” stuff (Bruce & Bruce, 1997). Good science outreach experiences can minimize barriers such as time by helping teachers fulfill their responsibilities and deliver the curriculum.

To make outreach effective, scientists must go beyond talking about what they do or lecturing; scientists must deliver the content in a hands-on manner that stimulates interest. Jane states, “Obviously the important thing is being interactive. Kids, if they touch and feel and play, they are not just listening to someone and they are going to learn better” (Jane, Administrator, February 14, 2012) This is supported by data from the survey (Figure 15) that indicated that 75% of participants felt that scientists should participate in outreach to be role models and inspire students. Further, 59% stated that it was to raise the level of scientific literacy of the general public. These results are consistent with findings in the literature that emphasize active learning (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008) and calls for scientists to communicate science and promote scientific literacy (Nature Neuroscience, 2009).

5.2.3 Support for Outreach

Interview participants stated that although they believe strongly in what they are doing, something more is needed to have an impact. Walker (2011), found that the scope of this problem is a strong coherent and cohesive argument in favour of more resources to support science learning and develop a partnership with the many organizations already involved in this area. Two reasons to develop partnerships are costs and access. In interviews, participants referenced cost as a barrier to outreach. Jennifer states: “One is funding, it is resources to build that informal system that works in partnership with the formal system” (Jennifer, Outreach Founder, February 10, 2012). Creating partnerships between outreach providers would allow for a pooling of resources and a whole that is more than the sum of the parts. It would allow for
multiple roles and perspectives, as well as access to expert performances and the modeling of processes, outlined in the Situated Cognition framework as necessary for learning to occur. This is consistent with findings discussed by a panel at the North-West Area Conference of the National Science Teachers Association (NSTA) meeting in December of 2011 in Seattle, Washington, that call for an authentic collaboration among businesses and other science, technology, engineering and mathematics (STEM) professionals (Smith, Rice, Lyons, & Novy-Hildesley, 2011).

However, given that Canada is a very large, yet scarcely populated country with diverse needs, the challenge is to create a model that is not only sustainable but also relevant to each community and school. Technology could be key to these relationships with another interviewee, stating:

Run a central website so we know who everybody else is and what everybody else is doing. We could share things but without a central, 3rd party to host this it’s not going to happen because nobody, none of these individual organizations has the resources to host for the whole. (Mark, Scientist, February 28, 2012)

The demand for a service like this is supported by data from the survey where participants were asked if it would be helpful to have one site where outreach opportunities could be accessed. An overwhelming 73% or 103 participants (Figure 18) indicated that yes, they felt this would be helpful as it would be easier to find and organize outreach activities. Further 4% or 6 participants indicated that they know of sites, but that they are not useful or up-to-date. This indicates that very few people know where to go to access or look for
outreach opportunities. Further, this resource would allow for a range of opportunities for excellent science education, both in school and outside, as the literature indicates because it is increasingly being recognized that society cannot rely on a single event to inspire future scientists (Laursen, Liston, Thiry, & Graf, 2007a).

Science outreach should provide opportunities for student and teacher engagement in a way that builds up momentum to create a cycle of self-sustaining collaborations. Support for outreach and these partnerships can be created and supported by empowering volunteers. According to Jane:

Have volunteers run workshops in their communities rather than us going to the community to recruit volunteers and to be their champion. It may be if they feel a little empowered, a little bit like this is their program a bit. Get them having discussions with teachers in a way that allows teachers to input what they really need and what they really want. So we are talking about creating a better relationship between a key volunteer or two or three in a community and school district so that now both these groups of people feel like it is their program and they are responsible for it. If you have buy-in from both, you will end up creating a better culture and a better community of acceptability in their community for a scientist to go into the classroom and talk to the kids. (Jane, Administrator, February 14, 2012)

These findings are similar to an approach described in the literature that calls for both supports at both the national and local levels (Leshner, 2008). This strategy of empowerment would support
collaboration in the construction of knowledge, an important instructional strategy (Lave & Wenger, 1991).

5.3 Summary

Finding suggest that secondary as opposed to elementary students are much more likely to be beneficiaries of science outreach, as are students whose teachers have a strong scientific educational background and exposure to science. However, teachers and outreach providers agree that science outreach needs to begin in the classroom and as early as possible to encourage students to enter STEM fields and to promote a strong scientific worldview. Effective science outreach can help teachers fulfil their responsibilities and deliver the curriculum as well as benefit the scientists’ themselves. However, this is dependent on scientists’ delivery of material in a hands-on and a timely manner. A local facilitator combined with support at the national level and tools, such as those provided through the use of technology, can help build relationships between teachers and outreach providers that are crucial for utilization of opportunities. In the final chapter of this thesis, I provide recommendations for teachers and science outreach providers regarding how to best approach and implement science outreach. I also answer my research questions and indicate areas for further research.
Chapter 6: Conclusions, Recommendations and Implications

In this chapter, key outcomes of the study in response to research questions 1 and 2 will be highlighted as conclusions. This will be followed by recommendations about science outreach, which will result in a proposed model in response to research question 3 (Figure 20). The chapter will end by a discussion on implications of the study’s results on theory and practice, curriculum, and future research.

1. What post-secondary educational backgrounds and contexts of work are represented among the participants? How can this data inform decision about potential target of science outreach?

2. In what ways and to what extent have the participants been involved in science outreach and what steps do they follow in planning and implementing outreach activities for inspiring a lifelong interest in science for children and youth and creating a greater awareness and understanding of science? What are the barriers encountered by the participants in this process?

3. What emergent model would be appropriate for use by both teachers and outreach providers so that the efforts of both allow for better utilization of outreach opportunities?

6.1 Conclusions

Scholars and researchers have stressed the need for real-life experiences and a range of opportunities for excellent science education in school and outside of it (Abbott, 2010; Alberts, 2009; Laursen, Liston, Thiry, & Graf, 2007a; Schwab, 1980). Emanating from the concerns of both scientists and teachers, a mixed method study was designed to explore the perceptions of science outreach by two stakeholders: teachers and outreach providers. Secondary as opposed to elementary students, especially grades 11 and 12, are more likely to be beneficiaries of science
outreach, as are students whose teachers’ have a strong scientific educational background and exposure to science. However, teachers and outreach providers agree that science outreach needs to begin in the classroom as early as possible to encourage students to enter STEM fields and to promote a strong scientific worldview. Therefore, these data can inform decisions about potential targets of science outreach by indicating that a concerted effort is needed to reach elementary school students, especially those students whose teachers do not have exposure to science or any connections to the scientific community.

Participants have been involved in science outreach in ways such as planning and implementing events such as Science Olympics and Science Fairs, and mentoring students. This is done in class and outside of class as an extra-curricular activity. However, the best science outreach is that which helps teachers to fulfil their responsibilities and deliver the curriculum, and also benefits the scientists themselves. Scientists should act as role models and mentors, stimulate interest in science through hands-on activities done at the correct level, and provide access to real-life contexts and opportunities in science. This usually requires training for the scientist and good communication between the scientist and teacher. Barriers to this process include time, in the context of a limited time for delivery of the curriculum, scheduling of the school, and time demands on the experts. Other barriers include engagement, cost, access, and level of comfort with science by the teacher.

6.2 Recommendations and Proposed Model

Various recommendations arise from this study. The first is the need for support at the national level in order to overcome such barriers as cost and access to science outreach. Science outreach needs to be more strongly coupled with the system in order to work more effectively
and to steer it where it should be going (elementary school) as opposed to where it is currently going – secondary school and classes whose teacher is already comfortable and experienced in science. The second recommendation is to use technology, specifically something like a website that lists potential partnerships and opportunities for teachers and outreach providers that would allow for better utilization and matching opportunities. This website must be up-to-date and hosted by a third party central organization, such as Youth Science Canada. Finally, as Canada is a large and diverse country, organizations should seek to empower a local, representative to coordinate relationships between the outreach providers and teachers, as they are more likely to understand the needs of the community and know other key members of the community. An emergent model appropriate for use by both teachers and outreach providers that allows for better utilization of outreach opportunities.

Figure 20: Proposed model for better utilization of science outreach as a method for science instruction
Often there is a disconnect between teachers and outreach providers, indicated by the dashed red line in Figure 20, in regards to coordinating and implementing science outreach. This model proposes the introduction of a bridging organization to help oversee and coordinate outreach opportunities, allowing for alternate communications pathways, indicated by the blue arrows (Figure 20). Further, what distinguishes this model is the central role of key community members creating multiple channels of communication. This organization, working in tandem with established outreach providers would be able to identify key members of both the educational and scientific community helping teachers and students most in need of assistance to create the connections to, and become part of the scientific community. In order to be effective, this organization would need support from the Ministry of Education, in regards to both funds and support. Funds would allow for the day-to-day costs associated with running such an organization, but also for tools that would allow for better utilization of outreach opportunities; for example, a current website listing potential outreach partnerships (Walker, 2011).

This model would allow for multiple channels of communication with the shared purpose of creating a community of practice (Lave & Wenger, 1991) with all of the associated benefits. This community would be identified by and share the joint purpose of promoting the sciences for today’s youth, and potentially recruiting others to become key members of this community, thus creating a self-sustaining cycle of outreach. This would ensure that all communities, not just urban centers, could conduct and benefit from science outreach in the classroom and support for events like Science Fairs.
6.3 Implications

6.3.1 Implications for Theory and Practice

Implications for theory and practice of this study include viewing science outreach as a method for delivering the curriculum as opposed to enrichment or an extracurricular activity. Further, for science outreach to be effective, teachers and scientists must embrace the idea that a range of opportunities and repeated exposure to cutting edge science are necessary to truly influence students and make an impact. Finally, stakeholders must see science as a dynamic outlook and as a way of thinking, behaving and viewing the world, as opposed to a body of knowledge in order to successfully utilize the potential that science outreach offers.

6.3.2 Implications for Curriculum

Curriculum can be better delivered by teachers who utilize science outreach as it provides the potential for increased student engagement, as scientists allow for delivery and understanding of “real stuff”. It would also allow teachers access to resources they might not have access to otherwise. Moreover, outreach opportunities have a potential to help teachers build an advanced understanding of a more advanced science topic and how it might fit into current school curriculum.

6.3.3 Implications for Research

Various implications for research arise from the given recommendations. These include how to find and list outreach opportunities on a website or through another technological tool and also determine who would fund and manage this website to ensure it remains current.
Additional research should also be undertaken to address the dichotomy that exists between the current beneficiaries of science outreach and where it is most essential. Finally, research into how best to locate and support a local representative of the community should also be undertaken to find out how best to approach this undertaking in the context of existing outreach organizations.
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Sage Publications, Inc.


Appendices

Appendix A: Survey Questionnaire

1. Have you read the provided consent form in regards to this study?
   - Yes
   - No

2. Are you interested in receiving a follow-up email with the results from this study?
   - Yes – please email me with the results from this survey (please provide email address in comments)
   - Yes – Please email me with the findings from your overall research (please provide email address in comments)
   - No – I am not interested
   - Other (please specify)

3. What grades do you teach?
   - K-2
   - 3-5
   - 6-7
   - 8-10
   - 11-12
   - College/University
   - Other (please specify)

4. At what kind of school do you teach?
   - Private/Independent
   - Public

5. What kind of degree do you have?
   - Science B.Sc. or higher
   - Math B.Sc. or higher
   - Engineering B.Sc. or higher
   - Computer Science B.Sc. or higher
   - Other (please specify)

6. Have you taken your/a class on a fieldtrip to a museum with a scientific exhibit?
   - Yes, in the past school year 2010-11
   - Yes, in the past 23 school years
   - Yes, in the past 45 school years
   - No
   - Other (please specify)

7. Have you taken your/a class on a fieldtrip to a university or other outside laboratory?
   - Yes, in the past school year 2010-11
   - Yes, in the past 2-3 school years
   - Yes, in the past 4-5 school years
8. Have you participated (judged, mentored students) in a science fair, challenge or similar event?
   - Yes, in the past school year 2010-11
   - Yes, in the past 2-3 school years
   - Yes, in the past 4-5 school years
   - No
   - Other (please specify)

9. Have you taken your/a class on a fieldtrip to a science center, planetarium or similar facility?
   - Yes, in the past school year 2010-11
   - Yes, in the past 2-3 school years
   - Yes, in the past 4-5 school years
   - No, but I would like to do it this year
   - No
   - Other (please specify)

10. Have you had a scientist come into the classroom to do an experiment or speak?
    - Yes, in the past school year 2010-11
    - Yes, in the past 2-3 school years
    - Yes, in the past 4-5 school years
    - No
    - Other (please specify)

11. Have you as a teacher done any professional development (PD) with scientists?
    - Yes, in the past school year 2010-11
    - Yes, in the past 2-3 school years
    - Yes, in the past 4-5 school years
    - No
    - Other (please specify)

12. In your opinion, who benefits the most from science outreach?
    - Students
    - Teachers
    - Parents/community
    - Scientists
    - Everyone benefits equally
    - Other (please specify)

13. In your opinion, who SHOULD benefit the most from science outreach?
    - Students
    - Teachers
    - Parents/community
14. What might prevent teachers from engaging in science outreach?
- Time: the teachers are too busy already
- PLOs: Hard to tie it to the curriculum
- Lack of access to outreach opportunities
- Remote location for external outreach
- Science outreach is not encouraged in schools
- Other (please specify)

15. Why should scientists participate in science outreach?
- To be role models & inspire students
- To raise the level of scientific literacy of general public
- To give back to the community that funds them
- To improve their communication skills to general public
- To inspire teachers and refresh their knowledge
- Other (please specify)

16. Why would you want to learn more about science outreach?
- It would be a great experience for my students and I want to learn more about available opportunities
- I am interested in science, I just don’t have a strong background and this would help me get ideas and supplement my lessons
- I want a role model for my students, or for them to get career ideas for their future
- It would help increase student motivation and their interest in science
- The scientists have access to equipment and information that I do not have (cutting edge science…) which will be of interest to the students
- Other (please specify)

17. If there was one site where you could access outreach opportunities would this help you access and take advantage more of outreach opportunities?
- Yes – It would be easier to find and organize outreach activities
- Yes – there are sites out there but they are not useful or up-to-date
- No – finding activities is not a problem
- No – I know of opportunities but there are other barriers in place
- Other (please specify)
Appendix B: Survey and Interview Consent Form

THE UNIVERSITY OF BRITISH COLUMBIA

University of British Columbia
Consent Agreement

Title: Science Outreach as a method of instruction: Examining the interactions of scientists and science teachers during outreach activities within the classroom

Dear Science Teachers and Scientists, you are being asked to participate in a research study. Before you give your consent to be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what you will be asked to do. If you are interested in participating in this study, please provide us with your email address so that we may contact you in the future. All contact information will be kept strictly confidential, and used only for the purposes of this study.

Principal Investigator:

Dr. Marina Milner-Bolotin
Assistant Professor
Department of Curriculum and Pedagogy
University of British Columbia
2125 Main Street
Vancouver, BC V6T 1Z4
Office: Scarfe Building 2326

Co-Investigator:

Ms. Romy Friedman
Graduate Student
Department of Curriculum and Pedagogy
University of British Columbia
2125 Main Street
Vancouver, BC V6T 1Z4

Purpose of the Study: To investigate the perceived disconnect between the two institutions/organizations and high school science teachers’ for the planning implementation of science outreach, and what available model would best harmonize the intentions of both stakeholders?

Description of the Study: The research study aims at exploring how high school science teachers and various organizations/institutions plan for, and implement science outreach as a educational instructional method within the
classroom. The results of this study will help the researchers (Dr. Marina Milner-Bolotin and Romy Friedman) to determine the areas of convergence and divergence in these plans. As a result, the researchers will be able to imagine and design an appropriate model that harmonizes the intentions of both teachers and outreach providers. The participants in the study from Catalyst will be asked to answer multiple-choice questions using clickers. Other participants will take part in a 30-45 minute long interview during the 2011-2012 school year. This interview will be recorded using a voice recorder. The voice recording of the interviews will only be conducted if the study participant agrees. In case, the participant does not agree to be recorded, the researchers will make written notes without recording.

**What is Experimental in this Study:** None of the interview questions used in this study are experimental in nature. The only experimental aspect of this study is the gathering of information for the purpose of analysis.

**Risks or Discomforts:** Although the researchers are not aware of the apparent risks of the study, we understand that you might feel uncomfortable answering all the questions during the interview. Should this situation arise, please discontinue answering the questions either temporarily or permanently and get in touch with Dr. Marina Milner-Bolotin or Ms. Romy as soon as possible.

**Benefits of the Study:** We expect you will benefit from participation in the study in the following ways:

a) Participants will have a chance to reflect on their use of science outreach as an instructional method thus having an opportunity to examine their pedagogies and explore ways of improving them.

b) Taking part in study will improve communications and inspire future outreach programs.

**Confidentiality:** All the data collected in the study will be strictly confidential and nobody except for the researchers will have access to it. All the data will be stored electronically on a password protected computer on a secure UBC server. The data will be erased and destroyed in five years after the completion of the study (Fall 2016). The confidentiality will be maintained during the publication of the results of the study: no names or any other personal information will be included in the publications.

**Incentives to Participate:** The participant will not be paid to participate in this study.

**Voluntary Nature of Participation:** Participation in this study is voluntary. Your choice of whether or not to participate will not influence your future relations with the University of British Columbia and the Department of Curriculum and Pedagogy of the Faculty of Education. If you decide to participate, you are free to withdraw your consent and to stop your participation at any time without penalty or loss of benefits to which you are allowed.

At any particular point in the study, you may refuse to answer any particular question or stop your participation altogether.

**Questions about the Study:** If you have any questions about the research now, please ask. If you have questions later about the research, you may contact.

Pl/Study Coordinator: Dr. Marina Milner-Bolotin

If you have questions regarding your rights as a human subject and participant in this study, you may contact the University of British Columbia Behavioural Research Ethics Board for information at the Office of Research Services:

Office of Research Services
TEF III # 102
6190 Agronomy Road
Vancouver, BC V6T 1Z3
http://www.ors.ubc.ca/
**Agreement:**
Your signature below indicates that you have read the information in this agreement and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to be in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this agreement.
You have been told that by signing this consent agreement you are not giving up any of your legal rights.

____________________________________  _______________________________________
Name of Participant (please print)     Email of Participant

_________________________________
Signature of Participant

_________________________________
Signature of Investigator

_________________________________
Date
Appendix C. Interview Script

Questions:

1) How do you go about your planning and implementation of science outreach activities? 
   What are the components and key steps?
2) How do you decide on the content and method of delivery of the outreach?
3) Why do you participate in science outreach?
4) What are the barriers in place that prevent science outreach opportunities? What could be 
   done to avoid or overcome these barriers in the future?
5) How do you address the needs of the various stakeholders?
6) Should scientists participate in science outreach? If so, why?
7) Should teachers participate in science outreach? If so, why?
8) Who are, in your view, benefits the most from science outreach?
9) What are the main difficulties for you in engaging in science outreach? Please give an 
   example.
10) What are the main benefits for you in engaging in science outreach? Please give an 
    example.
11) What defines an outreach program or event as successful? Can this be measured?
12) In an ideal world, what support system should be in place to make adoption of science 
    outreach in high schools smoother?
13) How is science outreach similar, and/or differ to other instructional methods employed by 
    teachers? By scientists?
14) Do you have anything else to add?
## Appendix D: Coding Scheme for Interviews

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<th>Coding Symbol</th>
<th>Category</th>
<th>Types of Comments</th>
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| MinEd         | Ministry of Education           | • There is no support whatsoever from the Ministry of Education for science fairs. It is not mentioned in any of their curriculum documents for example  
• Ministry of Education does not typically work in partnership with the Ministry of Research or Ministry of Economic Development. This causes, largely due to a lack of time or complexities of how government works, you don’t have that kind of horizontal integration.  
• To really have this affected, all these outreach activities, connections with scientists or fro that matter real artists or theatre actors or real lawyers that should be initiative promoted, aided and embedded by the ministry.  
• To really make progress, informal science promotion agency’s like TRUIMF and UBC have to be more strongly coupled with the system in order for this to work properly. It would work a lot better if we were working with the school boards and the ministry than in a lot of cases working against them. |
| Org           | Organization s                  | • STAN (Science technology awareness network)  
• VRoc (Virtual researcher on call)  
• Youth Science Affairs  
• Youth Science Canada  
• Canada Wide  
• TRIUMF  
• BC Innovation council |
| Del           | Delivery of material            | • Stop lecturing kids. Now the trouble with scientists is that is what we do, we lecture. So there is a slight disconnect there  
• They are a fabulous group because they not only reach out to the students, but they also reach out to the teachers and they give a combined set for when they leave. They don’t just leave with the experience, the teachers have training and understanding and a lesson in hand that they can do themselves. |
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| Sc           | Scale        | • In the Taimes Valley there are 150 elementary schools and about 37 high schools. So even if you wanted to send one scientist into one school, then you need a lot of scientists  
• Canada is a big place, you are looking at $800 to $1000 per head for an airfare (in regards to national science fair)  
• It needs a 3rd party to do it because even though everybody now understands it’s important, it’s not really a core not everybody sees it as core  
• Run a central website so we know who everybody else is and what everybody else is doing. We could share things but without a central, 3rd party to host this it’s not going to happen because nobody, none of these individual organizations has the resources to host for the whole |
| Tec          | Technology   | • They connect university researchers in their labs through television cameras so that the feed of the audio and visio is sent in the classroom  
• There is a lot of interest, and the recruiting of volunteers with web with classrooms  
• Part of the hope is using different kinds of technology you can have multiple kinds of experiences and therefore a deeper impact  
• There is such a lot of overwhelming technology that is now able to get used and you can’t get stuck in a really old mode of old lessons plans that don’t connect with the students. It has to be up to date and innovative and cool and funky. |
| MImp         | Measuring Impact | • No one has the time or energy to do long-term follow ups because if there is a value it is going to occur some years later  
• That’s a measure increase but outreach activities aren’t like that. All you can do is produce statistics on how many kids participate  
• It is much harder to measure what is the affect on that particular student  
• Partly of the other challenge of paying for it is a lack of long-term research again because of lack of ability to pay for it |
| Bar:C        | Barriers     | • In London we are struggling to rise money because we have one of the highest unemployment rates in the country  
• If you are going to invite a hundred judges to give up a day of their time you have to feed them, so there are real costs  
• It is getting very tough to get supply teachers because we don’t have any money  
• One is funding, it is resources to build that informal system that works in partnership with the formal system  
• In a lot of cases the school boards and Ministry are hindering, for example the decision not to fund teacher professional development workshops, or allow teachers to attend these workshops |
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| Bar:T         | Barriers       | - Teachers don’t have the time or energy to focus particularly on science fair experiences. Teachers have enormous demands on their time.  
- You can’t do additional things because you are constrained by the need to get through the material and you’ve only got a fairly limited time to do it.  
- Semestering makes it more challenging for teachers to put on science fairs.  
- There is so much that teachers have to cover, how are you going to fit this in. Can they spend a week on this or event two days and then subtract something else? |
|               | Time           |                                                                                           |                                                                                                     |
| Bar:R         | Barriers       | - The other part is the understanding of the value that together the partnership makes  
- So you ask everybody but it’s always the same names that actually step up and do something  
- Apathy  
- For the most part you are dealing with people who are already in a sense motivated. For people who don’t care, there is nothing you can do, you can’t force them. If you are in a classroom you can get to do something because they have to but when you are doing outreach it’s an elective… |
|               | Engagement     |                                                                                           |                                                                                                     |
| Bar:CwS       | Barriers       | - The number of people who are trained physicists going into high school teaching is way down, you don’t have the critical mass to do extra stuff  
- What we are doing is advanced science and the number of chemistry teachers who can appreciated advanced science or have a degree or they can begin to understand it is very very small  
- Well they want classroom resources, plug and play, something simple because a lot of them, like I said, aren’t comfortable with this material because they are not in physics, they didn’t take physics in university. |
<p>|               | Comfort with   |                                                                                           |                                                                                                     |
|               | science        |                                                                                           |                                                                                                     |
| Bar:A         | Barriers       | - I actually had to work hard to find teachers to do this and after a while I’m like why am I doing this? If you don’t want to come I am not going to kill myself. So eventually we stopped advertising, if somebody asks me and says hey are still doing that I am interested, I will do it for them |
|               | Access         |                                                                                           |                                                                                                     |</p>
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<th>Types of Comments</th>
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| Ben:St        | Benefits | • Get the experience of talking to some of the world’s top scientists and that just blows them away  
• They get to talk to some of the world’s top science students  
• When you take kids like that you open their eyes and open doors for them  
• Definitely changes attitudes around the possibilities of careers in those fields  
• So the science, the creativity, the communication skills that the students have is carefully evaluated by a lot of judges in their field on interest |
| Ben:Sc        | Benefits | • I had the privilege of getting to know some remarkable young people over the years so that’s what kept me going personally  
• The majority of our volunteers are post-secondary students. So the value to them o their student experience while they’re pursuing post-secondary is of considerable value to the host institution |
| Ben:T         | Benefits | • Real world context to some curriculum questions that teachers otherwise don’t have any resources for: ex, relativity, electromagnetism, circular motion |
| NI:BE         | Negative Implications | • 30 years before she where she was humiliated, not embarrassed, humiliated by her classroom teacher in front of her class giving her presentation for the first time |
| NI:A          | Negative Implications | • There are teachers who will bring in a group like that for one afternoon, one hour presentation and say “I’ve done science for the year” |
| PS:A          | Promoting science | • If we are going to build a society that embraces science learning we need to have them exposed to positive experiences throughout their life  
• STEM often comes down to “that’s a university thing and a senior high school thing”. From my perspective, the outreach needs to start with kindergarten teachers.  
• If our society wants to continue to be a leader in science in research, and I believe we are, then it has to start with the classroom.  
• A scientist is not just three or four letters after your name, it’s a certain way of thinking. |
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| PS:F          | Promoting science | • It was the early 90s and the recession at the time caused funding to be cut quite significantly form the science research council. That lead more of the science community to become quite concerned about how science and the value of research was being perceived by the public.  
• In CIHS grant there is a tick off box that you have to read and tick off before you can submit which basically says that having the ability to apply for grants means that you are also going to give your time to sit on peer review committee to work with youth in science fairs such as SingAp, so there’s an expectation that you are not just taking money in, you’re giving back to society. |
|               | Funding         |                                                                                                                                                                                                                    |
| PS:E          | Promoting science | • Over the years I just know who to talk to. You go back to the usual suspects. So there is probably half a dozen teachers I would go back and ask                                                                                         |