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Developing an Informal Science Education Program for Use in a Formal Setting

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An Interactive Qualifying Project Report completed in
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Abstract

In the past 20 years, Australian students have become troublingly disinterested in science and science-related careers. The Banksia Gardens Community Centre aims to address this issue with an in-school science education program. Utilizing the best practices in informal education, we implemented a pilot science program in three schools in Hume City, and left Banksia with a suite of activities and supporting materials for use in future programs. From our analysis of the pilot program, we concluded that hands-on activities are effective for engaging students, and that the pilot program was successful at cultivating their science interest. We recommend that educators develop these inquiry-based methods, and utilize similar outreach programs to encourage an interest in science.

Acknowledgements

At the completion of our project, we would like to thank all those involved in its success. This project has taught us much about group dynamics, allowed us to experience a new culture and environment, and allowed us to have an impact on large-scale issues. Overall, this was an unforgettable experience that we will take with us for the rest of our lives.

First and most importantly, we would like to thank Jaime de Loma-Osorio Ricón, our project liaison at Banksia Gardens Community Services. Jaime provided the utmost support and encouragement throughout our project development and implementation. We are grateful for the bond we have formed with him throughout this experience. Without Jaime's vision and knowledge for our project, we would not have had a project or been as successful as we were. We appreciate all you have done for us and the WPI projects past and future.

Next, we would like to thank the rest of the Banksia Gardens staff for welcoming us into your community and incorporating us into so many aspects of the centre. We would particularly like to thank Gina Dougall, Jonathan Chee, Natasha Alabakov, Mandy Ellis, Natasha Harby, Dhammika Jayawardene, Rachel Wood, and Greg Ferrington for their contributions to our project and experience. Everyone at the centre welcomed us immediately and made us feel at home.

For the success of all aspects and reliability of our project, we would like to thank all the members in the Melbourne and WPI community that met with us to discuss parts of our project. You gave us valuable information to validate our research.

With all the research and development we had, we were able to present our pilot program at three schools. We would like to thank the three participating schools and their science departments at Hume Central Secondary College, Roxburgh College, and Mount Ridley College, for allowing us to use your class time, and bearing with us as we developed and learned along the way. Without your cooperation, our project would not have been possible.

Next we would like to express with the utmost importance our appreciation for our two advisors, Andrea Bunting and Dominic Golding. Your devotion to all aspects of our projects was evident and extremely helpful through the Interactive Qualifying Project process and ID2050. Your insight, honest feedback, and recommendations were tremendously valuable to our group. In addition to the project role you played, we would also like to thank you for helping us acclimate to the Melbourne area and giving us insight on the city.

We would also like to thank the Director of the Melbourne Project Centre, Holly Ault, and the Interdisciplinary and Global Studies Division at WPI for organizing our project and accommodations. Without you, we would not have had this amazing experience in Australia.

We also owe a great amount of appreciation to the students of the past two WPI teams who developed the science education program at Banksia Gardens. Without you or your recommendations, our programs would not have been as successful.

In addition to those teams, we would also like to thank the other five WPI teams currently working on their own projects in Melbourne with us. We have appreciated your help, input, and support throughout the past two terms.

We have realised how fortunate we are to have been given this opportunity in Australia. We are grateful that we got to experience a side of Australia that most tourists do not get to see. We love that we got to influence students in a positive way in such an underprivileged area. The success of our project would not have been possible without all those people who helped us along the way.

Executive Summary

Background

There is strong evidence of a decline in the number of students studying science, technology, engineering, and mathematics (STEM) and entering the workforce in these fields (Lyons & Quinn, 2010). Between 1992 and 2009, the number of Australian students taking physics decreased by 31% and the number taking biology declined by 32% (Lyons & Quinn, 2010). Like other countries, Australia wants to stay competitive, but fears being left behind by countries such as China, Korea, and Singapore that have higher participation rates and performance scores in STEM subjects (Office of the Chief Scientist, 2012). To encourage students to go into technical fields, the Australian government, along with private organisations have started programs to get children interested in science at a young age. These programs emphasize hands-on inquiry based activities. To promote interest in science, we used a knowledge of the Hume City curriculum, combined with the effective informal teaching methods of Australian outreach programs such as those delivered by CSIRO to create a science education program for the Hume City community.

Methodology

The goal of this project was to develop, implement, and evaluate a science education program for Banksia Gardens Community Services, located in Broadmeadows, to use in local secondary schools. The project team identified six objectives to meet this goal. We:

1. Characterized the best practices for informal science education, and lessons learned from previous projects;
2. Clarified the nature and scope of the science education program desired by Banksia Gardens Community Services and participating schools;
3. Developed the appropriate educational materials including detailed program activities, instructions, and supporting documents;
4. Implemented the pilot program in selected local schools;
5. Evaluated the pilot program to identify needed modifications; and,
6. Suggested changes in the program for future development.

Before delivering our program we clarified its needs by interviewing the relevant staff at Banksia Gardens and the teachers whose classes we were presenting to. We compiled the activities we found and developed a single, living, Portfolio. We delivered the program, called *Give Science a Go* to three area schools, Hume Central Secondary College, Roxburgh College, and Mount Ridley College. We used a variety of evaluation techniques including pre- and post-intervention surveys for the students, our own observations of the students' interactions and reactions to the program, and an interview with each teacher after we delivered the program to gain information on their perspective of the program.

Based on the feedback from teachers, students, Banksia Gardens staff, and our own reflections on the programs, we make a series of recommendations about how Banksia Gardens might improve the implementation of these and similar programs in the future (see Chapter 5).

Conclusions and Recommendations

We live in a world surrounded by technology, and yet in the past twenty years, there has been a decline of science interest and literacy in many developed countries. We learned from our literature review and interviews with science educators that hands-on, inquiry-based approaches to teaching science are effective at engaging students. The Australian government created the national Inspiring Australia initiative to promote science interest in young students. In addition to national efforts, local community centres such as Banksia Gardens Community Services are making efforts to increase engagement in science in their communities. Banksia Gardens' efforts are focused on the underprivileged Broadmeadows community, where the disinterest in science is particularly high. In our work creating a pilot program for Banksia Gardens, we have drawn conclusions on the subjects of effective program execution, program content, evaluation methods, the target age group, and requirements for sustainability. On each of these topics, we also offer recommendations for the future development of the *Give Science a Go* program.

Program Execution

As we learned through the development of our science education pilot program, there are many challenges when working with local schools. There is always a variation in the commitment and response time of the teachers, and a difference in the amount of time each school can give for the program. We recommend that Banksia Gardens tries to identify teachers within schools that are excited and receptive of the new program to help support the development of the program in the future. We also recommend that Banksia Gardens work with science coordinators and principals at the schools to help promote the program and encourage more teachers to participate.

As seen through our background research on informal science education, we have determined that in order for our science education program to be successful, the students need to be exposed to the science activities over a longer period of time rather than just one day of the program. With this in mind, we recommend the ideal format of this science education program would include four 90-minute sessions for each school, spread out throughout the year, with one session per term. This ideal format may not always be feasible, so the facilitators of the program will need to adapt the format and schedule to fit the needs of each school.

As we have seen through our pilot program, students are often most engaged in activities that involve a competitive aspect. As suggested in the previous project conducted at Banksia Gardens, we recommend that Banksia Gardens hold an annual science competition or fair to promote the in-school science education program as well as get students excited about science outside of the classroom.

Content

The Portfolio covers a wide variety of topics and contains a large number of activities, but we recognize that the school curriculum may change and program facilitators may identify new topics and activities they wish to add. We recommend that Banksia Gardens treat the Portfolio as a living document that can be modified as the program develops. This would include adding new activities to the Portfolio, updating the current activities based on teacher, student, and facilitator feedback, and replacing broken hyperlinks to useful resources.

Based on feedback from teachers, we determined that when the program is implemented at the end of the school year, there is much more flexibility in the choice of subject for the program because students have typically finished their tests and covered all the required material. We recommend that Banksia Gardens try to offer its programs during these times in order to give facilitators more freedom to choose activities that are fun and wow the students with science even if they may not fit exactly to the curriculum

Evaluation

Evaluation is important to any informal science education program to ensure that the program is effective and is continually revised to better meet the needs of the local schools. Due to the time constraints of this project, the student surveys used could only measure the engagement of the students in the program, not retention of information. In order to do a complete evaluation of the effectiveness of the program we recommend that retention of information should be included. This could potentially include more learning based questions on the surveys or include an activity at the end of the session that tests how much information the students have retained from the session. We also recommend that whenever possible, the facilitators use the ideal schedule and format for evaluation (including pre- and post-intervention surveys of students and debriefings with teachers) in order to maximize the quality and quantity of useable data gathered.

Age Group

It has been shown that the declining interest in science and maths begins in years 6 and 7. Our program focused on students in years 9 and 10. From our pre- and post- intervention survey data, all our year 9 students who initially disliked science reported enjoying it more. However, several of our contacts believe that the greatest impact could be made on younger students. We recommend that Banksia Gardens considers adapting the program for a younger audience. There appears to be an opportunity to have a greater impact young students' attitude towards science, though more research on the optimum age group may be appropriate before making such a significant change to the program.

Sustainability

Developing, delivering, evaluating, and maintaining in-school science programs requires institutional commitment, funding, and dedicated volunteers and staff. Accordingly, we recommend that Banksia Gardens develops relationships with local universities to identify student volunteers who may be able to help. These students could help with the development of activities, offering supplies, or delivering the programs on their own, especially since a basic understanding of scientific concepts is required for effective program delivery. The Melbourne University Physics department has expressed interest in partnering with Banksia Gardens for any help needed in these areas. In addition to the universities, many members of the community may also be willing and able to volunteer. Many volunteers who come to the Centre on a daily basis have a science background. Utilizing these community members as well as university personnel would enhance the abilities of the Banksia staff to deliver these programs, especially since program delivery is more effective with multiple facilitators to assist in group activities in the classroom.

Teachers who have participated in the program may spread the word, but the program needs additional outreach and advertising if it is to be successful. We recommend that Banksia Gardens use their website to spread the word about the new program they offer. The website would include information about the logistics of the program, as well as potentially using teacher testimonials to support the past success. This would also emphasize how the program can accommodate to the curriculum. With the right publicity and personnel to help, the program should be able to be implemented easily and regularly.

Delivering in-school science programs along the lines of our pilot program can be an expensive proposition, in large part because high quality, hands-on, small group activities demand substantial staff time for preparation, delivery, and evaluation. Our Portfolio will help to reduce the up-front costs of developing the program, and the use of volunteers from the community and local universities can help reduce staffing costs associated with delivery. We recommend that Banksia Gardens look into philanthropic charity organisations that might be interested in promoting an interest in science for additional funding. The Hume City council has been aware of the efforts Banksia Gardens is doing to create this program, so we recommend that Banksia pursue these and other connections. Any help from local organisations will help promote the program in the Hume City area. We also found that buying program supplies for one class at a time becomes expensive quickly. To cut down on these costs, we recommend that Banksia Gardens seek cash or in-kind donations to develop activity kits for all the activities in the Portfolio. These kits would include all materials and instructions for a given activity, making it easier to gather supplies at the time of implementation. Utilizing volunteers to create these kits would also be beneficial and cut down the overall cost of a particular activity. Through the creation of kits and partnerships with charitable organisations, we believe the program can be sustained effectively in Banksia Gardens Community Services.

Authorship

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Chapter 2: Literature Review	ALL	All
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2.2 Informal Education Evaluation	Kyle Fitzpatrick-Schmidt	All
2.3 National Efforts to Promote Informal Science Education	Brittany Rhodes	All
2.4 Local Efforts to Promote Informal Science Education	Ned Shelton	All
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3.2 Objective 2: Clarify Program Needs	Ned Shelton	All
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3.6 Objective 6: Recommendations for Future Advancement	Michael Strickland	All
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4.2 Develop Appropriate Educational Materials	Brittany Rhodes	All
4.3 Evaluation of the Pilot Program	Michael Strickland	All
Chapter 5: Recommendations and Conclusions	Kyle Fitzpatrick-Schmidt and Ned Shelton	All

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

We live in a world surrounded by technology, and yet many developed countries are increasingly concerned about the decline in the number of students studying science, technology, engineering, and mathematics (STEM) and entering the workforce in these fields (Lyons & Quinn, 2010). Governments and corporations in the developed countries want to stay competitive, but fear they are being left behind by countries such as China, Korea, and Singapore that have higher participation rates and performance scores in STEM subjects (Office of the Chief Scientist, 2012). Many developed countries have enacted various programs to tackle the problem. For example, the United States government is trying to put more money into STEM in schools, and there are many organisations such as FIRST[1] (For Inspiration and Recognition of Science and Technology) working to get students interested in science (US Department of Education, 2010; FIRST, 2013). The Australian government is particularly concerned and has put a number of programs in place to try to address the problem. Australian corporations are also concerned about their ability to find employees with suitable skills. The Australian Industry Group recommends several strategies combat the problem, including "the adoption of a more innovative pedagogy which teaches STEM skills in an engaging and integrated way" (Australian Industry Group, 2013). The federal government and many other organisations in Australia have started numerous programs to foster student interest in science from an early age and to encourage them to pursue technical fields later in life. These programs range from the Australian Academy of Sciences "*Science by Doing*" program to the larger government initiative, "Inspire Australia". Teachers in the classroom are trying to incorporate new ways to engage students, but there are also after-school and in-school programs that supplement the efforts. Many community groups are helping to find a solution to the problem by providing some of these in-school and after-school programs. For example, Banksia Gardens Community Centre has offered "Magic Science Day", an interactive science program, and the "Little Bugs", which targets younger students, and several computer literacy classes. A complete list of the centre's programs is in Appendix A.

[1] FIRST is actually a multinational organization but was started in the US, and it remains the area with the largest participation.

Building on this background, the goal of this project was to develop, implement, and evaluate a science education program for Banksia Gardens Community Services for use in local schools. The project team identified six objectives to meet this goal. The six steps were to:

1. Characterize the best practices for informal science education, and lessons learned from previous Interactive Qualifying Projects;
2. Clarify the nature and scope of the science education program desired by Banksia Gardens Community Services and participating schools;
3. Develop the appropriate educational materials and activities;
4. Implement the pilot program in selected local schools;
5. Evaluate the pilot program to identify needed modifications; and,
6. Suggest changes for the future development of the program.

To achieve these objectives, we used several research methods including archival research, informant interviews, classroom and informal science observation, and qualitative evaluations from our experience with the project.

Chapter 2: Literature Review

Lack of science engagement is a noticeable problem in developed countries, and while governments, corporations and NGOs are developing programs to combat this, there are areas that slip through the cracks. One such area is Broadmeadows, where there are no existing science outreach programs outside of school. Banksia Gardens Community Services is trying to fill this gap by creating a pilot program to test in schools. This program will need to be evaluated to know if it will work. If the pilot is successful it will serve as the foundation for a larger program in the future.

2.1 Nature of the Science Problem

There is no question that there has been a decline in student interest in science in Australia. Between 1992 and 2009, the number of Australian students taking physics decreased by 31% and the number taking biology, 32% (Lyons & Quinn, 2010). While the Australian participation in elementary mathematics has risen slightly over the past fifteen years (Figure 1) the number of students taking intermediate and advanced maths has decreased by 7.6% and 4%, respectively, over this time (Lyons & Quinn, 2010).

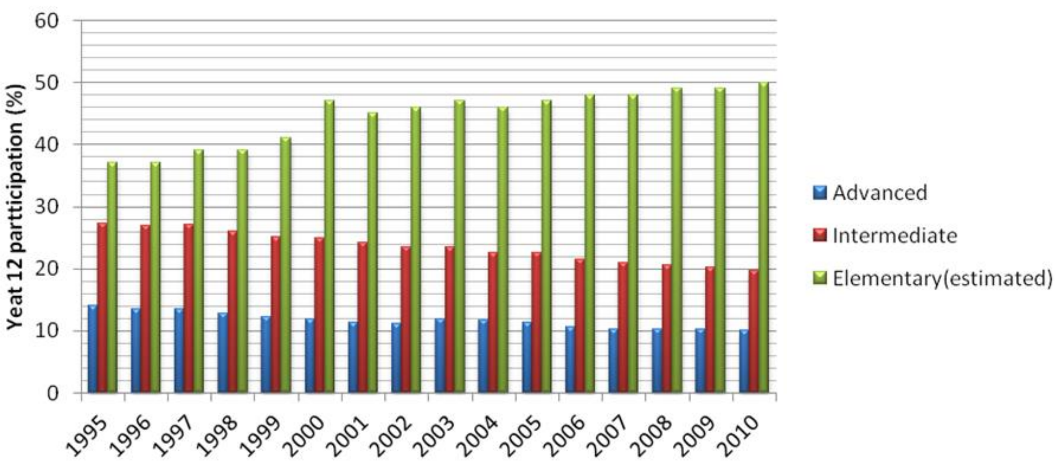

Figure 1: Student Participation in Mathematics 1995-2010 (based on Lyons and Quinn, 2010)

Where does Australia fall compared to OECD by TIMSS Scores? Australia was ranked 14th for science in years 4 and 8 and thirteenth for maths in 2009 and trails the US and England in all four areas (Figure 2) (Australian Bureau of Statistics, 2009).

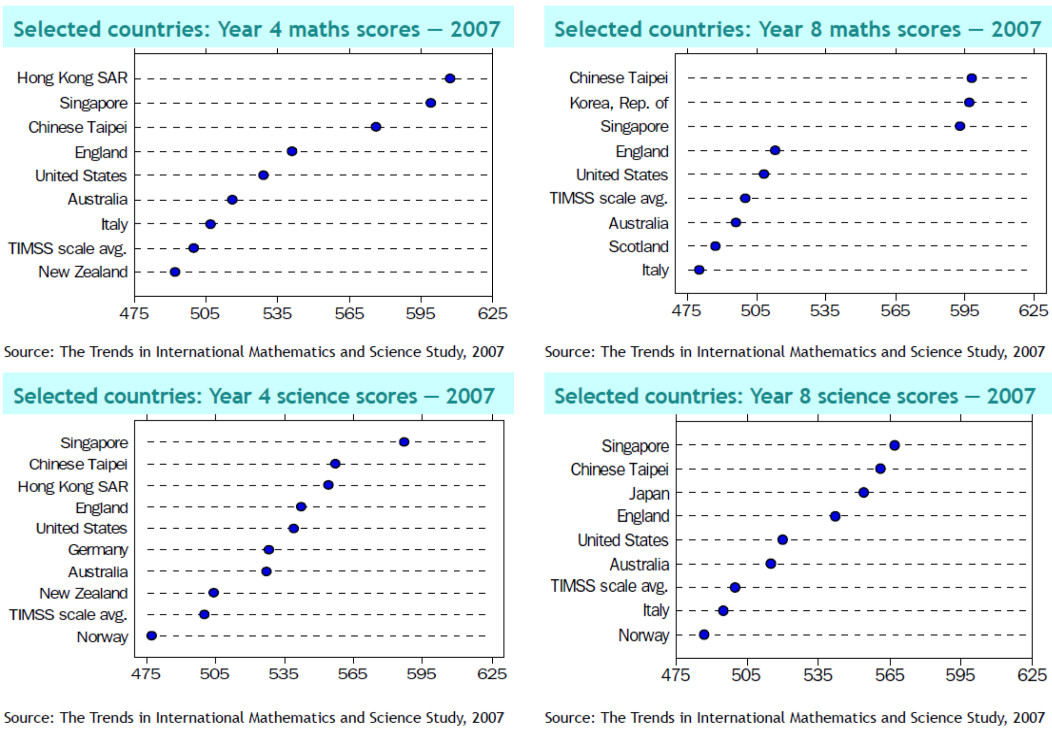

Figure 2: TIMSS Scores by Country (ABS, 2009)

The Australian Bureau of Statistics asserts that access to books and the internet, the amount of homework assigned, student backgrounds and attitudes are the key factors affecting participation rates and competency in science and mathematics. For example, the Bureau found that “Year four and Year eight students from homes with more than 100 books had significantly higher levels of maths and science achievement than those students with fewer books in the home” (ABS, 2009). Students receiving more science and maths homework had higher marks on exams, but Australian children were found to have less maths and science homework than students in other countries ABS, 2009). The same studies also showed that when students came from homes with parents that had higher levels of education, they also achieved better grades (ABS, 2009). Australian students gave several reasons for not choosing science. Thirty-three per cent of Year 10 students thought science was boring and 24% said they did not look forward to science class (Lyons & Quinn, 2010). This is not to say that no one likes science. In fact, 44% reported that science was the most interesting subject in school. The misconception that only those who wish to become scientists should learn about science appears to be one of the major reasons why students opt out of science. Indeed, two-thirds of year 11 students could not picture themselves as scientists and gave this as their reason for not taking science (Lyons & Quinn, 2010). Other students were not confident in their science skills and knowledge. This is referred to as the students' 'self-efficacy' (Gonzalez & Kuenzi, 2012). Gonzalez & Kuenzi (2012) find that students that think less of their science ability are less motivated to take science classes even if they are actually doing well in the class (based on exam scores). It is interesting that many students are overly critical of their science skills, and as a result choose not to pursue science. Since most students have made their career choices by year 12, the trends shown in Figure 3, with declining proportions of students taking maths, biology, chemistry, and physics, are especially troubling.

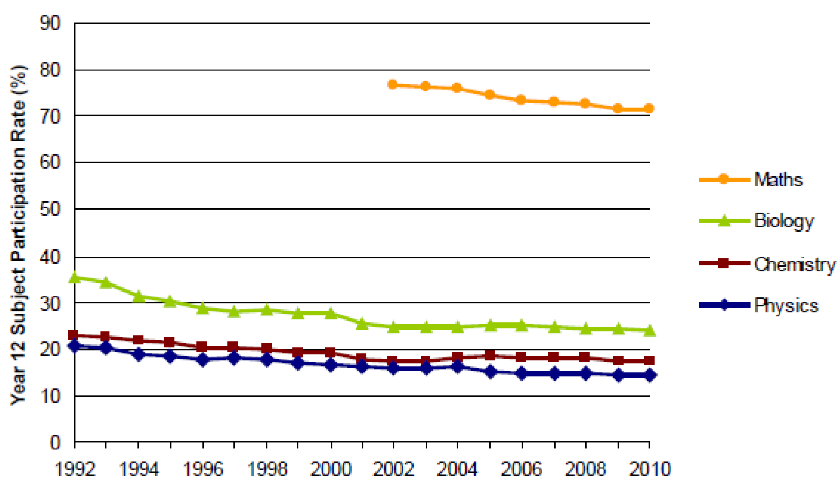

Figure 3: Year twelve participation in various STEM areas (Lyons and Quinn, 2010)

This decline in science participation is similar across the country but minority groups that have more limited access to resources such as books and computers appear to be less interested in STEM fields (ABS, 2009). More women are entering technology-based fields, but the number is still significantly smaller than the number of men in such positions (Gonzalez & Kuenzi, 2012).

2.2 Informal Education Evaluation

Many countries, including Australia, have tried various ways to tackle the problem of a lack of interest and participation in science and technology. One approach is to encourage an increased emphasis on science subjects in schools through a change in curriculum frameworks, standardized testing or other incentives to increase participation in science. Government agencies and other organisations in many countries have developed teacher training programs and offer professional development opportunities to encourage schools and teachers to adopt more hands-on, and inquiry-based approaches as part of the formal education system. Research indicates that these approaches are more engaging and may be more effective at encouraging learning, including impacts on knowledge acquisition and retention as well as changes in attitudes, behaviours, and skills. Although short term implementations of teacher development programs have been shown to make a small impact on the science engagement of students, an effort is being made to create more effective programs that further develop the engagement of students in science (Tytler, 2007). Another approach to increasing science interest is to bring informal science education into the classroom, which can be done by taking advantage of resources offered by museums, industries and community groups who provide informal science education activities to students. Teachers can also take their students outside of the classroom for informal science education through field trips to museums, environmental educations centres, and tours of different work places.

Crouch (2004) conducted a study into the retention of information of students from in class demonstrations and activities. In the study students were asked for an explanation of activities they had seen in class earlier in the semester. The study results showed that students who were asked to predict and discuss the results of the experiment retained more knowledge about the experiments compared to those that just observed. Indeed, students that only observed fared little better than students who had never seen the experiments at all. Stocklmayer (2010) indicated that "with a clear goal of inquiry, [hands-on activities] foster creativity and imagination." This focus on inquiry helps to engage the students because the activities are less like typical school labs or lectures. Specifically in Australia, a program is being developed called *Science by Doing*, which is using hands on learning to promote student understanding of covered material (Tytler, 2007). This demonstrates that doing leads to understanding and that interactive activities are a much better way to reach students than traditional demonstrations where students only watch.

Evaluations of informal science education can help us to understand the types of activities and techniques that have worked well and those that have not. It has been seen that students respond the best to hands-on, interactive activities. Students become engaged when the activities are relevant to their specific interests, but the activities need to be more fun and different from the approaches typically used in the formal education setting. At the same time, the demonstrations should also be closely linked to what students are learning in the classroom. Shmaefsky states:

> …it is important that demonstrations are carried out in a manner that contributes to the students' learning. Usually, there is little time in the curriculum for frivolous demonstrations. Furthermore, demonstrations done solely for fun detract from subsequent "serious" demonstrations and laboratory sessions. The "fun" should be the process of watching the principle in action (Shmaefsky, 2009).

The activities must be age appropriate. In order to engage all types of students, the activities must use a variety of senses that cater to the different types of learning styles.

In the eyes of the teachers, it is also important for the teachings to be linked to the curriculum, although sometimes students fail to see the importance of this aspect of informal education. When teaching an informal science education class, it is not always necessary to teach new material, but to "consolidate by linking experiences together in a meaningful way" (Rennie, 1994). Making the connections between inside and outside the classroom encourages students to become more engaged in hands-on activities since they can see the connections between what they have learned in school and the real world. This is known as *constructivism* and helps to pique the interest of the students inside the classroom and increase their interest in science in general.

According to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Science Education Centres, the opinions of the students about informal science education are best gauged through observations and interviews with the students, as well as interviews with the teachers. Teacher interviews help to confirm outside observations because they know the typical attitudes of their students towards science better than others (Rennie, 1994). Some other data collection techniques include audiotapes, videotapes, and questionnaires. The Australian Broadcasting Corporation attempts to teach in a similar way with their television and radio programs. The goal of a short visit or educational program is to attempt to change the opinions of the students in their attitudes towards science (Rennie, 1994). The different attitudes of students include attitudes towards science, towards scientists and towards the scientific method (Laforgia, 1988). This focuses on science education in the affective domain as opposed to the cognitive aspects. Typically there is a focus on the cognitive learning of the students, especially in the classroom. Informal science education leans towards focus on the affective domain because the attitudes of students towards science are just as important to learning as how much information has been retained (Koballa, 2013). Informal science education hopes to increase science interest in order to prompt more students to engage in scientific careers.

As seen in the book, *Learning Science in Informal Environments: People, Places, and Pursuits*, the first step to effective informal science education is to create an informal environment with specific goals for learning. An important factor to then consider is the learning styles of different students. Studies have observed that when each activity is catered to students with a variety of learning styles, more students will learn from the presented activities. Another tactic that has been found to be effective is to engage the students through supporting their own interpretation of the activities using their prior knowledge and interests. This idea of ties to prior knowledge connects back to the idea of constructivism. Connecting real life experiences to lessons learned in informal science education is very important. The incorporation of questions into the activities and demonstrations can also help the students make connections and conclusions about what they are experiencing (Bell, 2009).

Although many efforts have been made to evaluate the different types of informal education methods, there are no standardized methods of evaluation for these types of programs. Typical evaluations of hands-on, inquiry-based activities conducted in the formal and informal education settings focus on short-term measures of student satisfaction, engagement, and retention of facts, since it is much more difficult to measure longer-term impacts on skills, attitudes, knowledge, and behaviour. Long-term studies that try to assess impacts of such programs on decision making with regard to university courses and careers are even more scarce due to methodological difficulties and resource limitations. In spite of the scarcity of decisive evaluation studies, many educators in the formal and informal education sectors are convinced that hands-on, inquiry-based activities can be effective in promoting student engagement and learning in STEM fields.

2.3 National Efforts to Promote Informal Science Education

In an effort to address the declining interest in science among students in Australia, the federal governments as well as many other organisations have taken a multi-pronged approach to revamping the educational system. This involves evaluating the current formal teaching practices as well as encouraging new approaches to teaching. The government and different organisations are encouraging an increased emphasis on Science, Technology, Engineering, and Maths (STEM) in general, encouraging teachers to adopt hands-on, inquiry based approaches in the classroom, bringing informal science education groups to visit classrooms, and taking students out of the classroom on different field trips. There are also many other organisations working towards this common goal. One program, called *Science by Doing*, has been developed by the Australian Academy of Science with an innovative method for presenting the curriculum for teachers to use in a formal classroom setting. The three largest organisations working towards a solution via a science outreach program are the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Questacon, and the Australian Broadcasting Corporation (ABC) with science TV and radio shows. These three groups are cooperating to work with the federal government to develop a program that would encompass all of these aspects and present a government-funded plan, called *Inspiring Australia*, to promote student interest and participation in science.

Most students are exposed to the principles and practices of science through the formal educational system. Unfortunately, the methods and curriculum materials many primary school teachers use fail to effectively engage substantial segments of the student body, particularly those with less immediate interest in science. It is believed that the teaching principles currently used in primary schools have simply been passed on from generation to generation with little advancement or change. Many of the teaching methods are out-dated, so present students do not engage as well (Fitzgerald, 2012). Outreach programs can be very beneficial, but students spend most of their time learning in formal classroom settings. Typically students choose their career path before the age of 14 based on the topics that interest them most and give them the most satisfaction to pursue (Fitzgerald, 2012). One source claims that if an interest and ability in science is not instilled before the age of 14, students are unlikely to develop a liking for science in the future (Fitzgerald, 2012; Goodrum, Hackling, & Rennie, 2001). This is why it is so important to start teaching science in the primary schools in an engaging and effective fashion. To change the framework within the classroom, teachers are moving from teacher-centred approaches to student-driven explorations and inquiry-based learning. In these approaches, students participate in hands-on activities and experiments that link classroom lessons to relevant, real-world examples. The hope is that this will encourage students to want to learn more about the science behind the activity (Fitzgerald, 2012; Goodrum et al., 2001).

In an attempt to adjust the curriculum to inquiry-based learning, the government in Western Australia is working on changing the science curriculum to include "science inquiry skills; science understandings; science as a human endeavour; mathematics content; and, mathematics proficiency" (Ross, Beazley, & Collin, 2011). Putting this material into the curriculum really puts an emphasis on the new way of teaching science. With other major countries like the United States and parts of Asia increasingly emphasizing STEM, the authors assert that Australia needs to follow suit in order to stay competitive. To implement this curriculum with a STEM base, there will need to be immediate support in the schools for the current STEM educators and provide them with the tools they need. Many science experts and educators in Western Australia are in favour of these approaches and are pushing to get them implemented at the state level (Ross et al., 2011).

The Australian Academy of Science has developed a program called *Science by Doing* that is also intended to upgrade the formal science curriculum to make it more engaging for students by infusing it with hands-on, interactive, inquiry-based methods and materials. The creators of *Science by Doing* are working on developing the program into three-stages to make a set of ancillary materials that schools can use with their formal curriculum. All of the curriculum topics will be covered and taught by the teachers, but with a hands-on, inquiry-based approach. This program will be accessible to any Australian teacher online for a price, but all the materials will be included. Currently, the Australian Academy of Science is on the third and final stage of development. This stage includes developing a curriculum for the science programs they will present for the teachers. This way of helping teachers enlighten their students is unique in the fact that it focuses on the act of performing science. The program gives detailed instructions for teachers on approaches they may use to engage different types of learners in the classroom (Australian Academy of Science, 2013).

Outside of the classroom, many informal education efforts are also underway that aim to engage students in science learning. The largest science outreach program currently operating in Australia is conducted by CSIRO Education. This organisation was established in 1926 and is a major contributor to the Inspiring Australia initiative. Their focus is to lead in scientific explorations and educate members of the community. CSIRO in general and CSIRO Education in particular are involved in many research projects, educational outreach programs, national events (e.g., Science Week) and programming for TV and other media. During National Science week in 2011, CSIRO Education hosted an event called Experiment-a-Thon, which attracted more than 20,000 students and parents (CSIRO, 2012). There are CSIRO Education programs offered in schools in the Australian Capital Territory, New South Wales, Northern Territory, North and South Queensland, South Australia, Tasmania, Victoria, and Western Australia. In addition to this, they also are home to a Discovery Centre in the National Capital (CSIRO, 2010).

The CSIRO Education centres develop programs for in school and at home demonstrations. The focus of the outreach science program with CSIRO Education aims to instil an interest in science in children. With the focus on activities students of all ages, CSIRO Education delivers programs at schools that demonstrate science in a unique way. To further involve schools, CSIRO offers field trips to their facilities to show the research and opportunities there are at the company. In 2011, CSIRO Education had over 374,000 visitors come to their centres (CSIRO, 2012). CSIRO Education tries to reach students through various media, even extending all the way to having their own television show called SCOPE, which emphasizes that science is all around the world we live in and makes the connections to real life (TEN, 2013).

Various measures indicate that CSIRO Education has been very successful in meeting its outreach goals. Table 1 below indicates that its programs reach a large and growing audience. A survey in 2011 found that 40% of Australians were able to name at least one impact that CSIRO Education has had on their lives. The majority of respondents said they thought of CSIRO Education first when they thought of science outreach programs. Additionally, 99% of teachers visiting the CSIRO Education centres found the programs “engaging and educational” (CSIRO, 2012). CSIRO Education is one of the best-known science education developers in Australia that many other organisations try to emulate.

PROGRAM	2007	2008	2009	2010	2011
CSIRO Education Programs					
CSIRO Science Education Centres (visitors)	383,499	390,947	386,500	389,287	374,797
CSIRO Discovery Centre (visitors)	73,772	80,555	94,365	100,920	108,060
Double Helix Science Club (members)	19,545	20,253	19,656	15,821	13,851
Science by Email (subscribers)	28,516	29,560	34,933	38,156	41,204
Maths by Email[1] (subscribers)				9,255	14,967
CREativity in Science and Technology (CREST) (participants)	5,999	8,355	8,801	9,668	8,385
BHP Billiton Science Awards (participants)	4,103	2,568	3,114	3,658	3,770
Other Visitor Centres					
Parkes radio telescope (visitors)	104,783	92,369	112,342	95,104	96,609
Canberra Deep Space Communication Complex (visitors)	62,162	67,538	67,582	70,044	77,350

1 Launched in 2010

Table 1: CSIRO Science Outreach Participant Statistics (CSIRO, 2012)

Another organisation working on Inspiring Australia with the same common goal as CSIRO is Questacon, administered by the Australian Government Department of Industry, Innovation, Climate Change, Science, Research, and Tertiary Education (DIICCSRTE). Questacon is a National Science and Technology Centre that was built in 1988 in Canberra, now attracts over 400,000 people each year (Questacon, 2013c). This facility presents numerous exhibits and simulations designed to explain science and scientific concepts in engaging and intellectually accessible ways. Questacon's exhibits include *Caged Lightening* (high voltages are visualized with plasma and electric arcs), *Temperature Layers* (bottle of different colour water at different temperatures that separates based on density), *Cycloid* (race two balls down different tracks: one straight and short and one with a curved or cycloid track to see which is the fastest path) and many more (Questacon, 2013).

Outreach programs are a large part of Questacon's mission in addition to the exhibits and programs available onsite. Currently, the organisation offers two programs *Q2U* and *Shell Questacon Science Circus*. *Q2U* is an in-school program that is designed to engage students of various ages, interests, and abilities. It is provided to the schools at no cost and tailored to fit the curriculum needs of the school. *Shell Questacon Science Circus* is also an in-school program, but it is performed by students studying their Master's Degree in Science Communication

Outreach. The show includes activities similar to those that students might experience if they attended the Questacon centre, such as making a marble roller-coaster, borax slime, and a teabag rocket. The *Circus* also offers workshops for teacher development and events for senior secondary students to extend what they are learning in school (Questacon, 2013). Questacon realises the need for more science outreach programs so they are working hard to become a strong leader in the field.

Although the Australian Broadcasting Corporation (ABC) does not deal directly with students, it has the same vision of promoting science interest in young people and is a partner in *Inspiring Australia*. With 5 national science radio networks and 60 regional networks, the ABC has created a well-known radio foundation that other programs can learn from. There are different stations which each include different science topics of conversation for a variety of ages. The ABC also works to develop their programs through other media, like TV, where they have 3 national stations. Online, the ABC has over 3.8 million Web pages to teach people about upcoming science advances and interesting articles for all ages (Department of Innovation, 2010). This technique of presenting science material may not be new but it is relevant in today's world to keep up with other competitors through different technology. The efforts by ABC, Questacon, and CSIRO to develop the Inspiring Australia initiative are part of a larger set of initiatives and activities intended to promote science learning.

The Australian federal government realised the need to step in to help financially and logistically to create a nationwide science education program. The board members of CSIRO, Questacon, the ABC, and other science education representatives consulted over 230 Australian experts in the fields of science and education and recommended that the federal government develop a program to promote STEM learning through informal science. This program was called Inspiring Australia (Department of Innovation, 2010). The report, Inspiring Australia, said:

> Strong central leadership is needed to develop a vision, goals, priorities and desired outcomes for communicating science in Australia; to encourage greater collaboration and cooperation with and among relevant science organisations; and to ensure that the programs implemented through this national strategy are closely aligned with the Australian Government's strategic policy directions. In effect, national leadership will enable the nation to work together so that the whole becomes 'greater than the sum of its parts' (Department of Innovation, Industry, Science, and Research, p. 15).

The Government is promoting STEM through changes in both formal and informal education. Informal education has a special role in designing engaging programs and activities for disengaged learners. These programs are designed to be used inside and outside of schools. With strict evaluations of each program's success, different organisations and the Government can continue to help these promising groups to reverse the science decline. Lessons can be learned from the evaluations of informal science education efforts and then more closely at community-based programs (Department of Innovation, 2010). There are many organisations working with the government towards this goal nationally, but there is still a gap in their efforts. It is important for smaller communities to address the problem on their own as it is not always easy for these national programs to reach every spot of the country.

2.4 Local Efforts to Promote Informal Science Education

Community organisations like Banksia Gardens are supplementing the national efforts by CSIRO and Questacon to promote science interest and learning. These smaller organisations are especially important to the overall effort because they can cater to the needs of their local communities, which can include covering specific material to match a teacher's curriculum, appealing to a specific student demographic, price limitations, or travel restrictions.

National programs such as CSIRO do travel regionally for outreach programs, but they don't cover every suburb, and the programs can be too expensive for some schools. For a CSIRO science education program, the first visit costs $600. All subsequent visits cost $300 or more each (CSIRO, 2012). Other organisations, like Questacon, are limited by their location. Since Questacon is located in Canberra, ACT, they do not frequent the smaller suburbs like Broadmeadows. Schools also have the option to bring their students on field trips to CSIRO centres or museums, but run into the same cost restrictions that would prevent them from hosting a science program. Teachers are often over-stressed, and lack the resources to offer innovative inquiry based approach. Because community groups can be flexible with the timing and content of their science education programs, teachers often look forward to collaborations with them.

In addition to conforming to the price and travel restrictions of specific schools, community organisations can design their outreach programs to target specific demographics of students. In disadvantaged communities, there is a desperate need not only to increase interest in science, but learning in general. The socioeconomic disadvantage of the Broadmeadows community makes addressing the science education problem more challenging. SEIFA lists Broadmeadows as the second most disadvantaged suburb in Melbourne, the unemployment rate in 2011 was nearly triple the Melbourne average, and the area is the second most common destination for youth refugees in Melbourne (ABS, 2011). The area has a significantly lower average educational attainment (i.e., the percentage of residents who have completed year twelve or other diplomas), as shown in Figure 4. Incredibly, and most pertinent to us, was the measure that 40% of residents ages 15 to 19 years old are disengaged from any form of formal education, training, and employment (DEEWR, 2011).

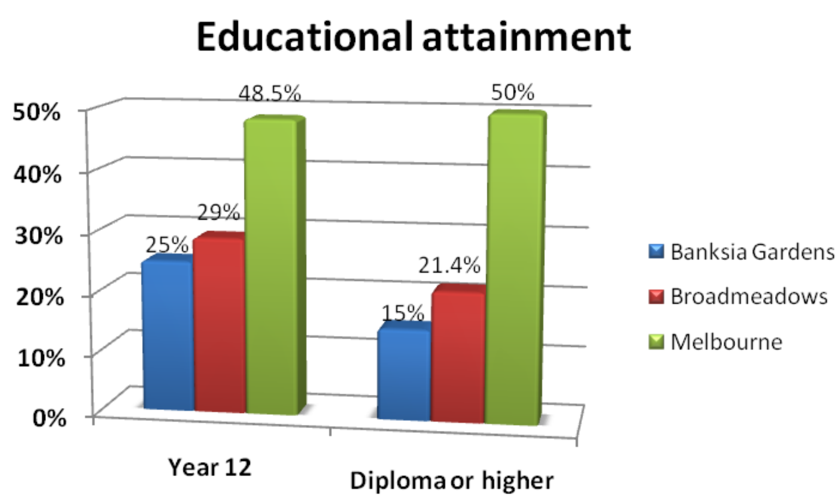

Figure 4: Educational attainment of Broadmeadows and Banksia Gardens (Banksia, 2013)

The Banksia Gardens Community Centre, which focuses on community development in Broadmeadows, offers several programs to encourage an interest in the sciences. These programs include after-school tutoring, courses on environmental sustainability, and *Magic Science Day*, which is a science education program for young students hosted at the community centre. Both the sustainability program and *Magic Science Day* are projects developed by previous WPI IQP groups. Building on the success of the Magic Science Day program, Banksia Gardens plans on developing an affordable in-school science program to reach more students(Wisheart, Smolko, De Obaldia, Allen, & Davis, 2013). The goal of the program, as stated by Wisheart et al., (2013, p. 27) who focused on creating a sustainable framework for the in-school program is "to promote interest in science and science-related careers amongst children from a culturally diverse and low socioeconomic background, as well as encourage children to stay in school."

To promote interest in science, we used a knowledge of the Broadmeadows curriculum, combined with the effective informal teaching methods of Australian outreach programs like CSIRO to create a science education program for the Broadmeadows community. Like Questacon's outreach program, we tailored the program's content and teaching style to suit the local community of schools. To evaluate the effectiveness of the education program, we used the best informal education education evaluation techniques we have reviewed, and improve the program based on the findings. Our procedure for this process is outlined in the following section, the methodology.

Chapter 3: Methodology

The goal of this project was to develop, implement, and evaluate a science education program for Banksia Gardens Community Services to use in local secondary schools. The project team identified six objectives to meet this goal. We:

1. Characterized the best practices for informal science education, and lessons learned from previous projects;
2. Clarified the nature and scope of the science education program desired by Banksia Gardens Community Services and participating schools;
3. Developed the appropriate educational materials including detailed program activities, instructions, and supporting documents;
4. Implemented the pilot program in selected local schools;
5. Evaluated the pilot program to identify needed modifications; and,
6. Suggested changes in the program for future development.

To achieve these objectives, we used several research methods including archival research, informant interviews, observations in classroom and informal education settings, and qualitative evaluation from our experience with the project.

3.1 Objective 1: Best Practices in Informal Science Education

We used a mixed method approach that incorporated archival research, key informant interviews, classroom observations, and other qualitative evaluation techniques. We supplemented our literature review with web-based searches to identify additional information on science education activities from both formal and informal education resources.

We conducted brief, semi-structured interviews with informal science education specialists in the United States and Australia. In the US, we interviewed Martha Cyr, the science outreach coordinator for Worcester Polytechnic Institute. In Melbourne, we interviewed representatives from Banksia Gardens, Jennifer Willis from Victoria University, John Bold from RMIT, Carly Siebentritt from CSIRO, and Milorad Cerovac from The King David School. We tried, unsuccessfully, to contact the Science Teachers Association of Victoria, but were able to use their online teaching resources. The interviews focused on best practices and lessons learned in conducting outreach programs and activities in schools to promote an interest in science, technology, engineering, and mathematics (STEM). The preamble and interview script can be found in Appendix B.

3.2 Objective 2: Clarify Program Needs

To ensure that our efforts in developing the science education program were well-directed, we first clarified the needs of the primary stakeholders in the Broadmeadows community, including staff at Banksia Gardens Community Services and teachers in the schools selected for the pilot program. This involved reviewing the information from the Banksia Annual General Meeting and the statistical data on Broadmeadows provided by Banksia Gardens, supplementing that knowledge with interviews from the Banksia Gardens staff, and when possible, interviewing the teachers at the participating schools prior to delivering the programs in the classrooms.

Building on our review of previous WPI projects conducted at Banksia Gardens, we held semi-structured, face-to-face interviews with selected staff members to clarify:

- Opinions on the companion projects conducted previously by WPI at Banksia Gardens;
- The impact of the science education programs at Banksia Gardens; and,
- Recommendations for our project and the future of the science program at Banksia Gardens.

  NOTE: The full list of interview questions with the Banksia Gardens staff is located in Appendix C.

In addition to these early interviews, we attended Banksia Gardens' Annual General Meeting on 30 October 2013, where staff members and volunteers reviewed all the programs and developments in the past year. On one afternoon each week, we assisted Banksia Gardens staff with various after school tutoring and other programs. Working with the Banksia Garden staff in this fashion allowed us to learn about their previous and ongoing programs and gave us a better idea of the goals, needs, and approaches taken by Banksia Gardens.

Before our arrival, the staff at Banksia Gardens already identified two schools, Hume Central Secondary College and Roxburgh College, which were willing to participate in the pilot program. Later, Banksia Gardens also recruited Mount Ridley College as a third participating school. Our initial plan was to develop a Science Activity Portfolio of sample presentations and activities, and discuss these activities and options with the teachers at each school before running the sessions. In actuality, we had much less time to prepare materials, and were able to meet with only one of three teachers in advance to discuss the format, content, and logistics of the planned program of activities.

At Mount Ridley College, we met with the teacher in advance to the program sessions and discussed:

- The nature of our project and our role at Banksia Gardens;
- How our previous sessions at other schools had been run, and what materials we had prepared. After the previous sessions we solicited feedback from the teacher about refinements for the subsequent session(s);
- The nature and needs of the science program at Mount Ridley College;
- What resources from the school would be available to us;
- If the presentation needed to strictly follow Mount Ridley's curriculum, or if the content could be in any science subject; and, the
- Logistics for our visit(s).

For the other schools, where we could not meet with the teacher in advance, we:

1. Researched the current science curriculum of each school;
2. Developed the presentations and activities to match the school's curriculum, as our contacts requested;
3. Presented 1 day of activities; and,
4. Used our observations of the students and any feedback we could glean from the teachers to refine the following week's presentation.

All of the interviews described above were conducted following the same basic protocols. The interviews began with a preamble that introduces the IQP group, explained the nature of the project and reason for interviews, explained that the interviewee may stop the interview or decline to answer questions, and asked permission to proceed and record responses. Following the preamble, we went on to discuss the points listed. The preamble and list of questions are available in Appendix D. The conversation did not always strictly follow the script, and we went into more detail on some questions, and covered new subjects when the interviewee brought them up. One or two team members led the discussion, while a scribe took notes. This method allowed us to either concentrate completely on the conversation, or on taking detailed notes. The notes are not verbatim, but captured the most important parts of the conversation.

3.3 Objective 3: Program Development

To compile a resource of activities, we developed a Portfolio or suite of activities, ancillary materials, and implementation instructions to give the Banksia Gardens staff and the teacher's flexibility to choose the activities appropriate for the designated delivery day. This Portfolio (Fitzpatrick-Schmidt et al., 2013) includes a user guide to explain the workings of the Portfolio, external resources for further information, and three sections of science topics with program materials. The three topics are Biology, Chemistry and Physics (physics is separated into Mechanics and Electricity and Magnetism), which are normally covered in year 9 and 10 curriculum. Within each science topic is a sample program outlining the cost and time for each activity for four sessions, information to include in a career connections presentation, surveys to evaluate the program, and numerous Running Sheets[2] to explain each activity in the science field. Each Running Sheet is comprised of:

- General information (recommended group size, cost, estimated time for completion, etc.);
- A summary of the activity;
- Background material for the facilitator and student's knowledge;
- A list of materials needed;
- The activity procedure;
- Facilitator questions and prompts to ask individual groups;
- Discussion questions to recap the activity as a whole class;

[2] Running sheet is the Australian term for a detailed itinerary of each in-class activity.

- Recommendations for implementation or helpful hints;
- Safety measures to be considered;
- Graphics that can be used in a presentation on the activity, and;
- A source to specific activity information.

NOTE: The actual Running Sheet template is located in Appendix E.

In order to develop this Portfolio, we reviewed activities and programs developed by other groups or organisations then refined them further to be more engaging and innovative. We modified the activities based on our group's specific strengths and interests (e.g., biomedical engineering and electrical engineering) to make them more fun and engaging for students while adhering to the requests of the participating teachers and the advice of our Banksia Gardens liaison and our advisors. Examples of possible activities that we included in the Portfolio are creating an artificial heart valve, levitating a piece of plastic using static electricity, and creating an electronic piano. Once we had a selection of activities within each topic, we narrowed down the options to ones that are feasible based on cost, reasonable time to complete the activity, and safety in the classroom. The possible activities were documented with great detail within the Portfolio using the list above to ensure specifics and logistics are worked out before implementing the program in local schools. Each activity that was used at a school was tested by our group to ensure that it worked well and we could identify the areas that may cause trouble. An electronic and hard copy of the Portfolio was left with the Banksia Gardens staff and is available as a supporting document to this report in the IQP database accessible through WPI's Gordon Library (http://www.wpi.edu/academics/library.html).

We planned to use the Portfolio in developing the schedule of each school visit. However, due to time constraints, we developed the materials for the Portfolio concurrently with the implementation of our pilot program. We used the information we identified (outlined in Objective 2) for each school to develop a set of educational activities and ancillary materials based on best practices in informal science education and the feedback we received from the participating teachers, Banksia Gardens staff, other education experts, and our advisors. Based on our background research, we designed the programs to be age-appropriate (for ages 13 to 16) and composed of interactive demonstrations or activities. We used tips we learned through our interviews to decide what practices and methods were best for facilitating these programs. These tips were gained from talking with university educators who teach aspiring teachers how to teach science, and other science educators. We tailored the demonstrations and activities to meet the needs of the current students and teachers. This included adapting our program to include whole class demonstrations and group activities to provide a variety of learning environments. In general though, our intention was to develop what we believe to be an effective way to deliver this type of material to instil an excitement for science in the students. We consulted with the Banksia Gardens staff and our advisors in an iterative fashion to develop the final program materials and protocols before implementing them in the schools.

We planned to outline the entirety of each program, including all sessions, before the first session, but with constant changes in the schedule and curriculum requirements of the schools, we altered our method of program development. Instead, we planned the programs one session at a time to allow us to analyse our observations and survey feedback, as well as take into account the informal debriefing with the participating teachers who expressed a desire for certain topics to be covered each visit. Thus, this made the process iterative and adaptive to the needs of each school and provided our team with lessons learned when delivering such programs. As a result, there are substantial differences in the content and evaluation of the activities that we actually conducted at each school.

In preparing for our visits to schools, we developed detailed schedules that outline the programs we wanted to include in each session. When creating the schedules, we needed to include time for our evaluation methods (surveys), introductions, demonstrations, and activities. To choose which activities and demonstrations were most relevant, we took several aspects into consideration: current topics being covered, allotted time at the school, and available materials at the schools. When we initially spoke with the teachers or science coordinators, we asked what the students were currently learning within the curriculum at the time of our visit so we could choose from the Portfolio the activities that were most appropriate. Table 2 below outlines all three of our school visits in our pilot program, and the activities conducted.

School	Date	Topics	Activities	Class Size	Duration (mins)
Hume Central Secondary College	October 21	Chemistry: Acids and bases	Acid and Bases Matching Game	20	110
	October 22	Chemistry: Acids and bases	Disappearing Ink Identify the Substance	20	110
	October 23	Chemistry: Acids and bases Chemistry: Career Connections	pH colours with Universal Indicator	20	50
Roxburgh College	November 12	Biology: Body Systems	Sweat Spot Heart Valve	22	100
	November 19	Physics E&M: Static Electricity Physics E&M: Light	Balloon Levitation Particle Separation Rainbows in Oil Pepper Printer	16	100
Mount Ridley College	December 5	Physics E&M: Static Electricity Physics E&M: Light Physics: Mechanics/Engineering Biology: Engineering	Balloon Levitation Need a Hand? Rainbows in Oil Catapults	19 and 22	120 x2
	December 6	Physics E&M: Static Electricity Physics E&M: Light Physics: Mechanics/Engineering Biology: Engineering	Balloon Levitation Need a Hand? Rainbows in Oil Catapults	35 and 40	120 x2

Table 2: Schedule of the three pilot programs

As one can see from Table 2, each school allocated a different amount of time for our visit. This required our team to choose activities for each session based on the constraints and influences of the school. In developing the activities, we needed to know how long each activity would take to complete in a classroom setting for our planning purposes. We had intended to test the activities at Banksia Gardens in an after-school or out-of-school program, but that was not possible. Instead we estimated times by conducting the activities within our own group. To conduct the tests, we needed to buy all of the materials listed for the activity on the Running Sheets in the Portfolio. We created a bill of materials, and presented them to the Banksia Gardens staff for approval, then bought the supplies. Once the testing was completed successfully, we double-checked that there were enough and the correct supplies to deliver the program in the school. The intention initially was to create an activity kit for each activity to be kept at Banksia Gardens. The kit would include all the materials to execute the activity and a Running Sheet for a facilitator to understand the procedure and materials. Since we created a large number of activities, and most materials for the activities were consumables, we only created one activity kit prototype for the Electric Piano activity. This kit specifically included all electronic components for five groups, directions, and a Running Sheet.

With all activities chosen for a given session, we then assigned facilitation roles within our own group and created presentations to go along with the activities. One member of our group would prepare to assume the role of the Lead Facilitator for a certain activity while the other members would prepare to take the role of a Group Facilitator. A Lead Facilitator was the expert on the activity and prepared to present the materials and directions to the entire group of students via a PowerPoint, class discussion, or demonstrations. A Group Facilitator planned to sit with a smaller group of students and lead them in the execution of the activities on a more individual basis. The Group Facilitator would discuss the activities with their own groups via questions and prompts provided on the Running Sheets. The last step of the program development was to conduct a test run of the presentations and activities within our group to ensure that we had sufficient amounts of the materials needed, that we would not exceed the time limit, that our group was aware of our own personal roles, and that we were confident on all the science topics being covered.

3.4 Objective 4: Implement Pilot Program

Three schools (Hume Central Secondary College, Roxburgh College, and Mount Ridley College) agreed to participate in the pilot program, which we called *Give Science a Go*. We worked with the Banksia Gardens staff, specifically Jaime de-Loma Osorio Ricón: Manager of Research, Innovation and Community Practice, to set up appointments at the schools. For the Hume Central and Roxburgh visits, we were working with the same class for all the visits. However for the Mount Ridley visits, each session was with a different class. The Mount Ridley program was delivered to a larger group of students comprising two classes.

Prior to visiting the schools, all of our materials were reviewed by both the staff at Banksia Gardens and the teachers at the schools. This included the list of activities, the materials we needed to do the projects, and our techniques for implementation and evaluation. For Hume Central Secondary College, the year 10 science class was covering acids and bases in chemistry, so the teacher requested that the activities be geared towards that topic. We had very little time for contact with the teacher before arriving at the school, so specifics on exact chemistry based activities desired by Hume Central was not discussed. Roxburgh College functioned in a similar way in that they wanted our activities to follow the curriculum as well. However, the science coordinator only communicated with us via email regarding the specific topics being covered in the class. We were not able to get direct communication with the actual teacher of the class that would be engaging in our program. At Roxburgh, we thought we would be delivering three sessions of biology related activities, but in reality the teacher only wanted the first day to cover this topic. The second and third sessions were based on electricity to follow the next subject in their curriculum. However, because of last minute conflicts at Roxburgh College, the last session was cancelled. Lastly, the science coordinator for Mount Ridley College was able to meet with us face-to-face 2 weeks prior to our scheduled visit. In this meeting, the science coordinator indicated that the four scheduled sessions did not need to follow a certain curriculum topic. Using these guidelines, we were able to apply the programs specifically to each school's needs. The details for all the activities can be found in the separate Portfolio document. We had hoped to meet with teachers before the delivery of the sessions at one of their regular staff meetings, but this proved to be infeasible given the timing of the activities.

We expected there to be twenty 25 students in each class. The structure of the activities included activities that involved the whole class, large groups, or small groups depending on materials, space, and time. Small groups were utilized most to promote small scale conversation for students to understand the science behind the activities better. In the small group setting, the facilitator had more time to devote to each student and a rapport was formed between the students and facilitator which is conducive for open discussion. During the programs, we asked that the teacher maintain order and discipline within the class if necessary, but not actively participate in facilitating the program. Before the program started, we talked with the teachers to ensure that they understood the purpose of this program and our expectations of them. We explained that informal interaction and experimentation were intended outcomes of the activities, so a reasonable degree of talking and joking among students was considered acceptable and not punishable offences. After each session of a program, we met to debrief with the participating teacher. In these discussions, we got a better understanding of what the participating teacher wanted in the next instalment of their program. In the example of Roxburgh College, this is where we were informed that the student's curriculum was moving on to electricity from biology. We took what we learned from these conversations and used that to improve the program for subsequent demonstrations at the same school, or at the second and third school.

3.5 Objective 5: Evaluation of Pilot Program

We used a variety of evaluation techniques to determine what aspects of the program worked well and where improvements would be necessary in the future. These evaluations included the pre- and post-intervention surveys for the students, our own observations of the students' interactions and reactions to the program, short student interviews and an interview with each teacher after we delivered the program to gain information on their perspective of the program. These evaluation techniques were created with input from both the Banksia Gardens and school staff members to ensure that we gathered the best possible data.

3.5.1 Pre-and post-intervention surveys:

We developed a pre- and post-intervention survey to administer to the years 9 and 10 students in the classrooms that we visited. The survey included age-appropriate questions intended to determine if students enjoyed the program, how their interests in science may have changed, and if they understood the basic science concepts that were introduced (see Appendix F and G respectively for the survey instruments). The survey also included an anonymous survey identification numbering system that allowed us to match the responses to the surveys for the same student without using names. We asked the students to fill out a series of boxes with different numbers and letters (first letter of last name, month of birthday, and number of siblings) to develop a unique identifier.

Administering a survey before as well as after program delivery allowed us to track the science interest of the students before and after the demonstrations as well as helped us to determine if the students understood the basic concepts show in the program.

We had hoped to administer the pre-intervention survey to the students a day or two before the presentation of the science program, but due to time and communication constraints with the teachers, this was not possible. Instead, we administered the pre-intervention survey when we arrived on the first day of the program before we introduced ourselves or began our introduction. We administered the post-intervention survey directly after the program had finished on each day of the program. We had hoped to deliver a follow up with a repeat survey the following week to measure student retention and interest but again due to time and logistical constraints, this was not possible. The second post-intervention survey was instead given on the last day of the multi-day programs. The second post-intervention survey can be found in Appendix H.

3.5.2 Observations:

We also observed the students during the program using an observation sheet (See Appendix I). This allowed us to make organized observations on how engaged the students were in the activities, and identify any problems that arose during the administration of the program. While the observations inform our overall findings and conclusions, we also used them to choose the activities and refine our delivery of them in subsequent sessions with the students.

3.5.3 Debriefing teachers:

In addition to learning about how much information and interest the students retained from the program, we also planned to gain the insight of the teachers about what they thought of the program. We did this through interviewing the teachers directly after the program using the interview guidelines that can be found in Appendix J. We amended these questions with help from the Banksia Gardens staff to gain the most pertinent information from the interviews and to be sure that we collected information that the staff would like to know about the program. While conducting the interview, all team members were present, one asked the questions and carried on the conversation, one took notes on the interview, and the other two made sure no information was missed. This allowed us to find out which topics and demonstrations the teachers liked, did not like, and which they thought were the most useful to their students. A conversational interview also allowed the teacher to include thoughts on topics that we may not have thought of initially in our topic guidelines. We also offered the teacher the option to give us a written review of the program if that was more convenient. We provided each teacher with some topic guidelines and questions to help guide the teacher feedback.

The advantage of a having conversational interview with the teachers is that we were able to prompt the teacher about the topics we were interested in and it allowed us to develop more questions during the interview depending on the direction of the teachers responses in addition to allowing them to state their own opinions of the program. The advantage to the written review was that we had an exact transcript of the teachers' own thoughts instead of just the group member's interpretation of the interview.

3.5.4 Actual School Evaluations:

We modified the choice of evaluation technique used at each school according to the desires of the teachers and differences in program content and logistics at each school. Table 3 outlines the evaluation procedures we used at each school.

School	Type of Evaluation				
	Observations	Pre-Intervention Survey	1st Post-Intervention Survey	2nd Post-Intervention Survey	Debrief with Teacher
Hume Central Secondary College	X				
Roxburgh College	X	X	X		X
Mount Ridley College	X	X		X	X

Table 3: Evaluations at Each School

At Hume Central Secondary College, the science program was primarily facilitated by our sponsor, Jaime de Loma-Osorio Ricón. Due to the limited amount of time between our arrival in Melbourne and the delivery of the program at Hume Central, our group was only able to make observations during the three consecutive days of the program. We were not able to survey the students or debrief with the teacher after the program. Nevertheless, this allowed us to observe closely how an experienced staff member handled the class and the delivery of the program, and also how students of this age level community acted inside the classroom. We learned important lessons that we applied to our delivery of the programs at Roxburgh and Mount Ridley.

At the second school, Roxburgh College, the program was delivered on 3 days spread out over 3 weeks. This allowed our group to administer the surveys in a similar fashion to our ideal evaluation method for this program. On the first day of the program we administered the pre-intervention survey before beginning the program. At the end of days one and two of the program we administered the first post-intervention survey. On the third and final day of the program, we administered the second post-intervention survey. We observed the student engagement and interactions using our observation checklist of all 3 days of the program. A short debrief with the teacher was done after the last session at this school.

At Mount Ridley College, we administered the pre-intervention survey before the beginning of the program. Due to the fact that we only had one session with each class at this school, we administered the second post-intervention survey at the end of the session. Observations were taken for each class during each of the sessions. A debrief with the teacher was done at the end of all sessions at this school.

After collecting the data from the student surveys, observations, and teacher interviews, we compiled the data and analysed the trends found in the data for the students' engagement in the program as well as their views on science. This helped us to see how effective the program was and which areas of the program needed work in the future. The quantitative data from the surveys was organized into a statistical analysis with graphs and tables, while the qualitative data from the teacher interviews was organized with direct quotations and narratives (Diamond, 1999).

3.6 Objective 6: Recommendations for Future Advancement

Based on the feedback from teachers, students, Banksia Gardens staff, and our own reflections on the programs, we make a series of recommendations about how Banksia Gardens might improve the implementation of these and similar programs in the future (see Chapter 5). We also make some more general recommendations regarding the state of the field of science education and the need for additional research on the effectiveness and evaluation of these kinds of hands-on, inquiry-based programs and activities.

Chapter 4: Findings

The overall goal of our project was to develop, implement, and evaluate a science education program for Banksia Gardens Community Services. We have broken our findings into three sections. First, we present our findings on best practices based on the interviews we conducted with educators that supplement the literature review. These findings helped shape the way we developed and delivered the in-school programs. Next we summarize the overall structure and content of the Portfolio of materials that we developed for future use by Banksia Gardens. Lastly, we present the findings from our evaluations and observations of the pilot programs delivered in three schools, including the lessons we learned along the way.

4.1 Best Practices

Much has been learned over the years about the need for and value of hands-on, inquiry based methods of teaching. Organisations specializing in informal education have advocated for these practices, and while many teachers have been encouraged to use these techniques in their teaching, implementing such practices in the formal education environment is often difficult due to limitations of time, resources, and requirements to focus on curriculum frameworks. Teacher training programs and other professional development opportunities encourage schools and teachers to include hands-on, inquiry-based activities into the everyday routine of the classroom. Research indicates that these approaches are more engaging and may be more effective at encouraging learning, including improving knowledge acquisition and retention as well as attitudes, behaviours, and skills. By providing both in-school and out-of-school activities and programs, especially in less affluent communities, outside organisations can help the formal education sector achieve the overall goal of increasing student interest and proficiency in science (Tytler, 2007).

To tease out in more detail the approaches and best practices that have been employed in Australia in particular, we interviewed several experts in the science education field to learn from their personal observations. These specialists included informal education experts, university educators, secondary school educators, and Banksia Gardens staff members who primarily deal with the educational programs offered at the centre. Milorad Cerovac, a secondary school physics teacher and the FIRST Robotics coach for his school, emphasized that student disinterest in science typically starts in the middle school years (personal communication, December 2, 2013). He stressed that to reverse the problem, efforts should start with younger students so that when they get to secondary school, they are more likely to be intrigued by the subject and want to pursue their interest through science courses offered at that level. Other researchers (e.g., Goodrum, Hackling, & Rennie, 2001) found similarly that if an interest and ability in science is not instilled before the age of 14, students are unlikely to develop a liking for science subsequently. We asked Carly Siebentritt, who is the Inspiring Australia Project Officer at CSIRO Education, what ages should be targeted most for these kinds of science outreach efforts. From her own experience with CSIRO, she felt that students certainly need to be exposed to engaging, hands-on science activities before years 9 and 10, but emphasized that such interactions should be promoted throughout all the school years to keep students interested and motivated as they grow older (personal communication, December 3, 2013). These perspectives do not negate the value of programs such as ours that target year 9 and 10 students, but indeed emphasize the need to develop similar programs for all ages in order to engage students throughout all their schooling.

Our correspondence with John Bold, Education Program Director at the Royal Melbourne Institute of Technology (RMIT), and Jennifer Willis, retired professor at Victoria University, re-affirmed what our literature review revealed that hands-on, inquiry-based activities are the best way to engage students. In both interviews, the experts emphasized the need to be creative with the presentation of educational materials and to be prepared with numerous different kinds of activities to spark the interest of students with different interests, skills, and abilities (J. Willis, personal communication, November 19, 2013; J. Bold, personal communication, November 27, 2013). Willis also emphasized that science classes should not be about taking notes, but should include two or three different activities, maybe more depending on the length of the class. With this type of classroom dynamic, preparation and a passion for the materials and the process are essential. Our experiences in delivering the programs in Broadmeadows confirmed this advice. We found that we had to prepare carefully and extensively in advance of program delivery, which meant trying out the activities numerous times before our visit, developing interesting graphics to accompany what we were delivering, and choosing what we believe are the most engaging and relevant activities. In addition to passion and preparation, we might add practice as a third essential ingredient. We believe that our final sessions at Mt. Ridley College received very positive feedback from students and staff, in large part because we had practiced our techniques in delivering the previous programs and were consequently better prepared and more able to convey our passion for the subject.

John Bold also emphasized the need for real-life physical examples of the material being taught to enable students to make the connection between the classroom and the world. We thought this would be very valuable for certain activities, like the “Need a Hand?” activity we had designed in which students make a prosthetic hand using common materials. We endeavoured to secure a prosthetic hand from the National Centre for Prosthetics and Orthotics Department at LaTrobe University for our final program delivery at Mt. Ridley College but were unsuccessful. We recommend, however, that Banksia Gardens and other groups conducting similar kinds of programs in schools should try to secure pertinent real-life objects that can help students better relate more abstract concepts to everyday life.

As noted in the literature review, science outreach programs are being used all over Australia to promote student engagement and learning in science. Sometimes it works best to have an unfamiliar face teach students. Students tend to get comfortable with their teacher and may not pay as much attention to the material being presented. Outreach programs are geared to engage the students and address a bigger issue, in this case, increasing interest in science. Science outreach educators can take advantage of the fact that they are not the ‘normal’ teacher so the focus can be on the engagement, not more narrowly-defined schedules, curriculum requirements, and discipline. Carly Siebentritt (personal communication, December 3, 2013) stressed that outreach educators can use their status as ‘outsiders’ to their advantage by engaging students in activities that are fun and distinctively different than those typically conducted in a formal educational setting.

It is extremely difficult to measure the impact one outreach program may have on participants. Often students participate in a program with their class, not by choice, so surveys are not taken seriously, resulting in data that does not always portray exactly how students felt. In addition, measuring how much a student is engaged or has retained is nearly impossible in a 1 day program. Siebentritt uses the technique of taking note how many students say “thank you” after the completion of a program. Although it may simply be manners for a student to do this, it can also mean that students truly want to thank you for opening up the different science opportunities that are possible. With the quantitative data acquired through the surveys (see below), we are able to see immediate reactions to the program and compare them to pre-intervention surveys. A suggestion from Martha Cyr, Science Outreach Coordinator at WPI, was to create a chart (Table 4) at the top of each survey to give each student an identification code. This kept the student anonymous, but allows us to track their progress (personal communication, October 3, 2013).

First Letter of Surname	How many siblings do you have?	Number of month you were born

Table 4: Chart used to identify students anonymously

This chart proved to be very useful in our analysis. However, a few students forgot to fill this out so we could not trace some responses to a particular student. We tried to minimize this limitation by reviewing the surveys quickly as the students turned them in, but this proved difficult in the rush of the beginning and end of a class period.

Now that the pilot program has been completed, Banksia Gardens has a clearer understanding of the value of such programs and the potential for future outreach efforts. Banksia Gardens would like to expand their ability to offer such programs, since they believe that improving proficiency and interest in science is important. The Centre has seen students get excited about science experiments conducted as part of the Holiday Program that includes *Magic Science Day*. The science component is not the major selling point of the program, but the staff has indicated that students enjoy and are excited about this component. Bringing this type of program into a school is important to Banksia Gardens because they can open students up to other options in the future (N. Alabakov, personal communication, December 5, 2013). Unfortunately, Jonathan Chee, Community Development Manager at Banksia Gardens was worried about the ability of Banksia Gardens to sustain, let alone expand the program in the future (personal communication, November 21, 2013). One option Chee mentioned might be the possibility of training volunteers at the Centre to implement the programs in the schools. We have developed a Portfolio of materials with detailed instructions for implementation (as described in the following section) that Banksia Gardens can use to train volunteers and other staff in program delivery in local schools.

4.2 Developing the Portfolio of Educational Materials

From previous research performed at Banksia Gardens Community Services Centre and communication with Jaime de-Loma Osorio Ricón, Banksia Gardens Manager of Research, Innovation, and Community Practice, we knew that the science education pilot program would be integrated into the current ninth and tenth year curriculum at three Hume City schools (Wisheart et al., 2013). At two of the schools we visited (Hume Central Secondary College and Roxburgh College), the science coordinator requested that the programs be closely aligned with the curriculum and what the students were learning at the time of the in-class delivery. Therefore, we turned to the Australian Curriculum, Assessment, and Reporting Authority (ACARA) to provide an idea of what science topics we should expect Australian students to be studying from years K-12. ACARA is an organization tasked with developing the Australian national curriculum, assessment programs, and reporting programs for Australian schools (ACARA, 2011). On their website, ACARA briefly lists the science achievement standard of each academic year. The subjects for years 9 and 10 are listed in Table 5 below.

Subject	Year 9	Year 10
Biological Sciences	Multicellular Organisms and Ecosystems	DNA and Genes, Evolution and Natural Selection
Chemical Sciences	Atomic Structure, Chemical Reactions and Their Importance	Atomic Properties and the Periodic Table, Types and Rates of Chemical Reactions
Earth and Space Sciences	Plate Tectonics	Global Systems and Astronomical Features
Physical Sciences	Wave and Particle Models of Energy Transfer	Energy Conservation and Transformation, Laws of Motion

Table 5: ACARA standard science curriculum for years 9 and 10 (ACARA, 2012)

We used these topic areas to guide us in our search for appropriate materials and activities. The ACARA curriculum, however, is still in the process of being adopted across the country and has even become a controversial political issue (Patty, 2010; Blake, 2013). Because of the likelihood of curricular deviations from the ACARA model, we also researched the science topics being covered at each of the schools where the program would be implemented. Table 6 below shows the science curriculum of Roxburgh College, which is similar to the ACARA model, but has significant enough differences to warrant changes in Banksia Garden's science program to keep the two in line.

Subject	Year 9	Year 10
Biological Sciences	Organ Systems	Microbiology, GM Food
Chemical Sciences	Atomic Structure, The Periodic Table	Atomic Properties and the Periodic Table, Types and Rates of Chemical Reactions, Stoichiometry
Physical Sciences	Electric Circuits	

Table 6: Roxburgh College's 2013 Science Curriculum (Roxburgh College, 2013)

Using these data as a base, we created a Science Activity Portfolio for Banksia Gardens to use. Many organisations, including Banksia Gardens, need a suite of high quality materials and instructions to train volunteers going into the schools to implement science outreach programs. Our Portfolio provides them with all the necessary materials and instructions to plan a program, prepare presentations, and relate activities to careers. It comprises a total of 29 hands-on activities. What separates this Portfolio from other activity databases that we found available elsewhere is that each activity is accompanied by explicit instructions and supporting documentation for the facilitator. Each activity is presented in such a way that anyone with a basic science background can understand and implement them; we also provided questions and prompts to promote discussion in small groups and as a whole class. As far as we can tell from our review of extant materials, this all-inclusive approach is unique to our project and intended to make future program implementation easy. We gathered many of the basic materials from three main online databases highlighted by Martha Cyr (personal communication, October 3, 2013). These were www.nsdl.org (owned by the University Corporation for Atmospheric Research), www.teachengineering.org (owned by a group of engineering and information systems teachers who have partnered with American Universities, including WPI), and www.instructables.com (owned by Autodesk). We read through numerous activities on these sites and chose those activities that we thought were most suitable based on the recommended age, the level of hands-on interaction, how long each would take to complete, and the relevance of the subject material to the curriculum. After we documented the main features of each activity in the Running Sheets, we added in the facilitator information based on our own knowledge and some external sources to ensure clarity and content accuracy. Some activities were developed completely on our own and cannot be found on any of these online databases. For such novel activities that lack supporting citations, we included extra graphics and background information to ensure clarity and completeness.

The Portfolio is divided into numerous sections ranging from the program planning process to specific questions that facilitates can ask students during the activity. At the beginning of the Portfolio a *User Notes* section describes how the Portfolio is divided up and how to maintain the Portfolio as a living document by correcting mistakes and updating links to external sources. After this, the Portfolio is divided into three sections: Biology, Chemistry, and Physics. Since physics is a large topic, we divided that section to separate mechanics activities from electricity and magnetism activities. At the beginning of each science topic, we provided a sample program. Based on feedback from the schools and Banksia Gardens staff, we assume that a program at a school would comprise one 90-minute session per term for a year (i.e., four sessions/year total) being delivered to one classroom of students. This sample program also includes the cost for each activity, the estimated time for each activity, and a graph depicting which parts of the session would be devoted to evaluation, activities, 'wow-factors[3],' and presentations. To illustrate what is included in the Portfolio, the sample biology program is shown in Figure 5 below.

[3] A 'Wow-Factor' is a short demonstration to catch the attention of the classroom and stimulate an interest in the program

First day:	**Time (min)**	**Cost**	
Program Introduction	10	0	
Sweat Spots	20	25.5	
Heart Valve	45	60	**Total**
Post evaluation 1 /clean up	10	0	85
Second day:			
Daily Introduction	5	0	
Cheshire Cat	10	41	
DNA extraction	45	56.5	
Strong Bones Part 1	20	45	**Total**
Post eval 2/clean up	10	0	90
Third day:			
Daily Introduction	5		
Need a Hand?	45	42	
Body Systems Bingo	30	6	**Total**
Post eval 3 /clean up	10	0	90
Fourth day:			
Daily Introduction	5	0	
Breathing Thorugh Straws	10	8	
Strong Bones Part 2	20	0	
After image	10	31.5	
Career connections	20	0	**Total**
Post eval 4 /clean up	25	0	90
	TOTAL COST	316	**Total**
	COST /STUDENT	12.6	355
Time Breakdown			
Wow factor	30		
Activity	225		
Presentation	45		
Evaluation	55	355	

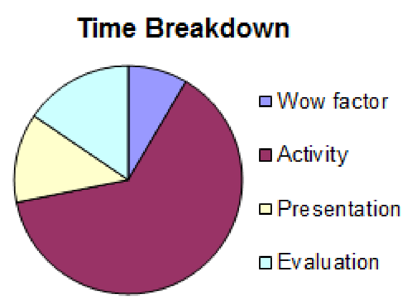

Figure 5: Biology Sample Program included in the Portfolio

After the sample program is laid out, the Portfolio lists out possible careers in the subject that people may not normally associate with the subject. This list includes bulleted information for what each career entails, making it easier for the facilitator to include and input into a PowerPoint presentation. In addition to the information, we also included pictures and links to videos for most of the careers. The purpose of this section is to wrap up the entire program on the last session with a connection to the real world. Following the career section, we include surveys specific to the sample program to make it easier for the facilitator to print.

Following the sample material in the Portfolio is the compilation of all the Running Sheets, which is the majority of the document. To illustrate each section of the running sheet, we used one of the activities that our group developed completely called *Need a Hand*, where students construct a prosthetic hand out of common materials. The Running Sheet starts with basic information at the top, shown in Figure 6, to give the facilitator an overview of the activity. If the facilitator thinks the activity is interesting and appropriate, they can continue reading to get the entire instructions.

Need a Hand (45 Minutes)

Estimated Time for Activity: 45 Minutes
Recommended Age Range: Year 8-12
Recommended Group Size: 4
Estimated Price for 25 Student Class: $15
Activity Subject: Biology and Life Sciences / Engineering

Summary of the Activity: This activity allows students to get creative and try to engineer a prosthetic hand out of household items. The students will work on a team to achieve the goal of having the fingers close.

Figure 6: Basic Running Sheet information for "Need a Hand"

The next major part of the Running Sheet is the complete list of instructions for implementation. Each section is labelled to indicate whether the Primary or Group Facilitator is responsible. The first section presented by the Primary Facilitator comprises the Background on the activity, which is what the facilitator needs to know, but also information that can be explained to the students prior to the activity to introduce the basic knowledge needed to do the activity. Following the first section, the next step is for the facilitators to distribute all materials to each group. Under this section, the user can find all the materials for one group to complete the activity. It also notes which materials will be provided by Banksia Gardens. The third step is the Experiment Procedure, which is presented to the entire class by the Primary Facilitator. The fourth and fifth sections are where we separate our instructions from other types of activity databases. Section 4 is titled Facilitator Questions and Hints and outlines how a Group Facilitator can encourage discussion about the activity within the small groups. Some of the questions are open ended so there is no correct answer, but others require a specific answer that demonstrates an understanding of the science behind the activity, and those questions include the answer and, in some cases, a hint. After the groups have finished discussing the activity, the Primary Facilitator brings the class back together to discuss as a whole group. This discussion is outlined in section 5, called Discussion/Take Away. These two sections are shown in the "Need a Hand" example in Figure 7.

4. Facilitator Questions and Hints [Group Facilitators]
- What brainstorming techniques did you use?
- What problems did you encounter in your design?
- How did you overcome these problems?
- How do you think you could make your design better?

5. Discussion/Take Away[Primary Facilitator]
- There are many different ways to build prosthetics that have different advantages and disadvantages
- Teamwork is imperative to engineering projects for a compilation of ideas

Figure 7: Example of Sections 4 and 5 for "Need a Hand"

Once all of the steps for the execution of the activity are covered, the Running Sheet continues to a section that gives recommendations for implementation. This section can include a tip that we or other subsequent facilitators learned when we ran the activity, possible solutions to engineering activities, or general external information that the facilitator would need to know. Immediately following this will be a section identifying any safety concerns. For activities where this information not required this section will be excluded from the Running Sheet. To create a presentation on the material needed to complete each activity, we also included a section called Graphics for Presentation. Any pictures that might be helpful in an explanation of the science would be included here. Lastly, if the activity is based on an activity from the internet, we cited the source. There are a total of 29 Running Sheets included in the Portfolio separated into their respective subjects.

The final section of the Portfolio is the External References. Because many of these activities were based on existing activities, we gave links to the three online databases that we used for our activity development. Banksia Gardens can use this section to find additional activities if needed, as well as obtain additional information on a particular activity. In the Running Sheets that were compiled from existing activities, we included a citation as the last section, but links can often be changed or broken. To keep this Portfolio up to date, we hope that future facilitators can update the Running Sheet citations as required. It is hoped that these external links will lead the facilitator to the activity on the internet where they can replace the broken link with the new one. For the full Portfolio, refer to the external document.

The Portfolio was given to Banksia Gardens as a hard copy with tabs to facilitate its use. In addition to the hard copy, we provided the Banksia Gardens staff with an electronic version, which allowed staff and volunteers to update links, add new activities, and print surveys and Running Sheets as necessary. The electronic copy also included a Table of Contents with 'clickable' titles. This allowed the user to quickly jump to whatever section they please and not have to sift through the entire document. With all of this information compiled in one place, Banksia Gardens can use the Portfolio as a guide to planning and implementing the science programs in the future. Our group used these documents throughout the execution of the pilot program and was able to evaluate the success of each program because of the components in this document.

4.3 Evaluation of the Pilot Program

Evaluation is an essential component of designing any new educational program, and yet evaluation of educational programs only started in the mid-1960s and is still in its infancy (Ball, 2011). Evaluating educational programs is extremely difficult, but increasingly the funding and indeed the future of science programs depend on compelling evidence that the programs are effective (Ball, 2011). Due to time constraints, the variety of the school schedules, and changing demands for program content, we were unable to collect the same kinds of evaluation data at each school. Consequently, we will explain the findings from each school separately.

4.3.1 Hume Central Secondary College

The program at Hume Central Secondary College was held on the first 3 days of our project work in Australia. Due to our lack of preparation time, our sponsor from Banksia Gardens, Jaime de Loma-Osorio Ricón, took over most of the planning. We decided to use this visit more as an observation period to get accustomed to the age group, Australian curriculum, and nuances of teaching. The program was scheduled for three 75-minute lessons running on consecutive days, and included the topics of acids and bases in Chemistry.

The first day started with an introduction to our group and Banksia Gardens Community Services. We had the students introduce themselves as well. We then had asked the students to stand and move to a different part of the room based on their interest in science. One side of the room was for students who say they like science and the other side of the room for those who do not like science. From this, we found that initially 16 students liked science and 3 did not like science. We then repeated the activity, this time based on if they like chemistry or not. We added a middle section for students who were unsure if they liked chemistry. From this, we found that eleven liked chemistry, six were unsure, and two did not like chemistry. After the introduction, our sponsor, Jaime, gave a lecture on the basics of acids and bases. Based on our research, we found that students prefer to do more interactive activities than listening to information. From our observations, we found that students were not as interested in the lecture portion of the program as much as others. We then proceeded to identify their current knowledge by playing a matching game: each group was asked to match chemistry terms with their definitions. This allowed us to see which students would participate as well as how much they already knew. From this activity, we found that most students knew the material but there were some students that we knew would need more help to become more engaged in future activities. We took note of these results so that we could modify the following day's session accordingly.

The second day consisted of a lengthy activity. We broke the class into groups and each member of our group was assigned to a group of about five students. We made disappearing ink within the small groups. Jaime began the activity by introducing basic knowledge that each group would need to complete the activity. The students were then instructed on how to create the solution, and then they all tested it on paper and cloth. The ink disappeared, but when the students added sodium hydroxide to the dried ink, the intention was that the ink would reappear. Unfortunately, this did not happen successfully for every group. This could be because we were using diluted phenolphthalein dye or a small amount of it so the ink was not dark enough to reappear. However, the majority of the students did participate fully in the creation of the solution and were not that upset that the activity didn't work fully. We then asked each group go to the front of the room and present what happened with their ink and why. This gave students a chance to learn how to talk in front of a crowd while teaching their classmates the science behind the activity. After the activity, Jaime passed out jars of unknown substances to each group. He asked each group to try to identify what each item was based on smell and the pH colour by using a universal indicator. This activity did not go as well because our group was unaware that the activity was planned for the day and we did not know ourselves what the items were beforehand to steer our groups in the right direction. This activity was also right at the end of the class with little time to really work on it.

The third day started with an in-class demonstration. We mixed an acid and a universal indicator dye in a beaker, then added a base to change the pH of the solution, which changed the solution's colour. To change the colour again, we continued to add more bases so that the solution passed through all of the colours. To share a better demonstration, we showed a video of a similar activity that used dry ice to change a solution from a base to an acid. The students just observed the change; they did not do any of the activity personally. Our group then gave a presentation on chemistry careers. The point of this was to show students that there are more careers you can have within chemistry besides just being a chemist. We gave examples like making fireworks, makeup, and chemical engineering. After the presentation, we had a discussion with the students about what careers they would like to pursue. From this, we found that 14 wanted to pursue a career in engineering and science, were interested in non-science related field, and 6 were undecided.

Based on our observations, our group thought that overall the program was to the point, but could have been more engaging. We had only a couple activities and we felt as though we could have had more if time had allowed. We also had ample time for each day so we feel as though we could be more prepared with extra activities in the future. Some students were more passionate and involved than others, and there were few who did not participate at all. We found our program to be successful because the students were in a new environment that they could participate in.

As noted in Chapter 3 above, we were able only to conduct observations at this school. We could not conduct pre- or post-intervention surveys and nor were we able to debrief with the teacher. A few of the things that we noticed were:

- Some students did not want to participate at all;
- Some students were engaged but not participating; and
- The students warmed up to activities throughout the session and across the days.

The students who were engaged but not participating were an interesting challenge, since it was hard to tell if they were engaged or not if they were just sitting there without giving any input to the activity. At the end of the last day, we asked if the students liked the program and we received a positive response. Overall, we found the session to be successful but with much room for improvement. We made note of all our observations to see how we could improve the format for the next school.

4.3.2 Roxburgh College

Roxburgh College was our second school to visit, and the first one where we prepared all the activities, materials, and presentations. By this time, we had more than a week to research and prepare activities. We had intended to conduct an interview with Marina Savic, the participating teacher at Roxburgh, to ask her about what content she would like, what materials were available for us, and other logistical problems, but we were unable to. We did, however, have some email communication with our other Roxburgh contact Lisa Perry, the science coordinator, which outlined the science curriculum and some of the materials we would have available. Our presentations were scheduled to be on the Tuesday of each week, for three consecutive weeks. This allowed us to present to the same group of students each week and develop each consecutive week's program based on feedback from the previous week. However, the last of the three presentations was cancelled because of a school assembly. The subjects we covered were the human body, electricity and magnetism, and the third session would have been on electric circuits. The class sizes at Roxburgh were 16 and 21 students. To obtain feedback from each class, we issued the pre-intervention survey on the first day, and a post-intervention survey at the end of each presentation.

As we had done in the first session at Hume Central, we began by introducing ourselves and Jaime, talking about where we were from, and why we were at Roxburgh. Again, we asked the students to move between two sides of the room based on their interest in science. We also took part in this activity, to try to encourage our students to honestly answer. This activity, used in our first meeting with each group of students, was a useful tool to gauge a class's general attitude toward science. After that, we continued our PowerPoint presentation. In our PowerPoint slides, we kept the technical data and text to a minimum, using colourful pictures to illustrate concepts we were explaining, rather than relying on written explanations. Our first activity, which was intended to be a "wow factor" that would quickly inspire an interest in the rest of our program, was called "Sweat Spots." One presenter asked the class questions about the integumentary system to gauge their knowledge of how skin works. We then had short discussions about sweat and its purpose and mechanics. Finally, we asked "How many sweat glands do you have, and how big are they?" as expected, no one had a good estimation. We then explained that we had an experiment to figure that out. The sweat spot experiment consisted of rubbing betadine on one of everyone's fingers, letting it dry, powdering the same fingers with corn flour, and observing what happened with a magnifying glass. Typically, a purple spots would appear at each sweat gland as the sweat allowed the corn flour and betadine to react. Our classroom was cool though, and few people were sweating enough for the spots to show up. The experiment did work for some students though, and we tried to let everyone see those fingers. Despite our "wow factor" not actually working, the students were still interested in the subject and did not openly complain.

Following the experiment clean-up, we quickly moved on to our first engineering activity, building one-way heart valves, shown in Figure 8. Our presentation at this point primed the students with descriptions of how one-way valves work, how heart valves work, and some prosthetic heart valve designs. The activity was presented as an engineering challenge between teams of five classmates to create the best prosthetic heart valve. Our criteria for a good heart valve was that it allowed water forced by a syringe to flow through the valve easily one way, but not the other. Each group also had Jaime de Loma-Osorio Ricón, or one member of our group working with them. Here, our jobs were to encourage each group to ask science and engineering questions about their design, keep them on task, and hint towards a design that might work well. In this activity, our students were very engaged, and with only a few exceptions, everyone was participating. When it came time for the competition, the students were interested in the other designs, but disappointed that there was no prize for the winning team. We made a note then of Jaime's suggestion to bring sweets as incentives for later programs. At that point, we had reached the end of our time block, and gave the post-intervention surveys.

Figure 8: Roxburgh College students showing their winning Heart Valve design

Based on the feedback from the first session and our conversations with Jaime, we designed the second session to have more short activities, and less PowerPoint time. Before the first session, we had prepared content for all 3 weeks, but learned that Marina had already finished teaching the section on biology, and suggested that we move on to electricity and magnetism. As our wow-factor for the second session at Roxburgh, we began with a balloon levitation activity in which we used static electricity to levitate strips of plastic bags over balloons, shown in Figure 9. We presented the demonstration as a magic trick, and asked the class to figure out how it worked. We expected them to have already covered static electricity in the science class, but a scheduling change meant that our presentation was their introduction to static electricity. As a result, we spent more time than we had planned going over the properties of static electricity.

Figure 9: Roxburgh College Student levitating a piece of plastic with a balloon

Next, we moved on to the particle separation engineering challenge, in which teams tried to separate salt from pepper using static electricity. We did not develop the rules for this competition enough; the goal was simply to be the first team to separate the salt and pepper, but it was difficult to measure exactly when the pepper was separated well enough. Since the rules weren't very clear, the students didn't treat the activity as a competition, but still completed it. As with all the non-wow factor activities, we followed up the particle separation competition with some discussion of practical applications for electrical particle separation.

Following the particle separation, we moved on to the thin film interference experiment, shown in Figure 10. In this light-based experiment, students observed the patterns of colours that a thin film of nail polish on water creates, due to thin film interference. We gave a brief explanation of the phenomenon before the experiment, but the underlying physics was far beyond the year 9 science curriculum. The most effective way to convey what was happening was to compare the rainbow pattern to those seen on bubbles, oil slicks, and other thin films, and the similarities between each case. In the actual experiment, the students were very excited as they heard other groups talking about their observations. We spent extra time experimenting with the nail polish, because the students were so engaged in this one activity.

Afterward, we presented another experiment which mimicked the mechanism in photocopiers that uses static electricity to move ink to paper. In this experiment, pepper adhered to an electrically charged static sheet, but only where a specific charge had been applied, which allows the students to visualize how the static charge moves around the sheet. The pepper tended to stick to the entire sheet, which somewhat ruined the experiment. Because it wasn't working, we cut the last experiment short to talk about why it might not be working, and how static electricity is used in printers. The particle separation and pepper printer activities were set up as to let the students experiment with technology that exists in the world around them. That is, to make the connections that the information they learn in school are used for more than just answering the questions at the end of the chapter. Despite two of our four activities not going as planned, the students reported that they enjoyed the day of activities. Overall, the engagement for the second day was better than the first, especially during the thin film experiment.

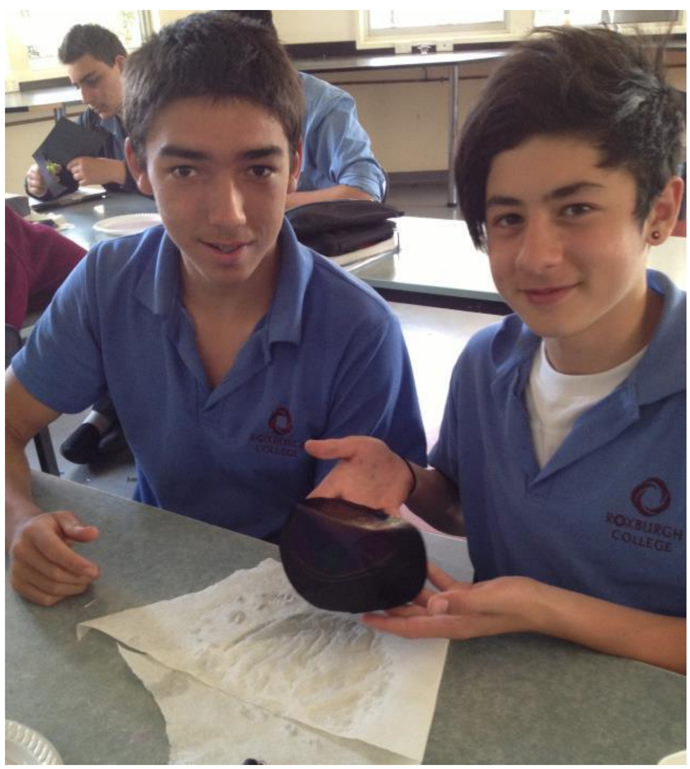

Figure 10: Roxburgh College students participating in the "Rainbows in Oil" activity

We had more time to prepare for our Roxburgh College visit and as a result we had surveys prepared for the students to fill out at the beginning of the first session and the end of each session. One of the questions the students was asked was to rank the activities in order of how much they liked them. The responses to the students ranking for the first day are shown in Figure 11 below.

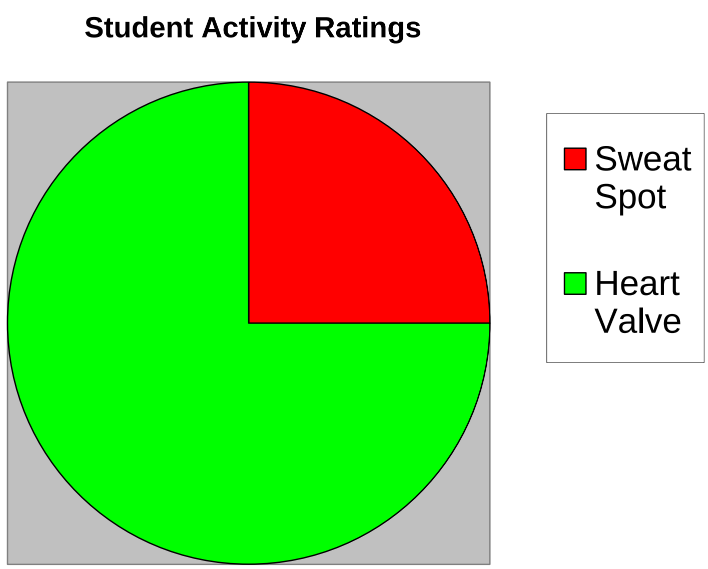

Figure 11: Percentage of students who ranked each activity their favourite

This indicates that the heart valve activity was the most popular with 75% of the students ranking it their number one choice. The rankings of the second day's activities are shown in Figure 12. This data shows that the most popular activity was "Rainbows in water" with 10 students rating it their favourite, and the second most popular activity was the balloon with 9 students rating in their second favourite choice.

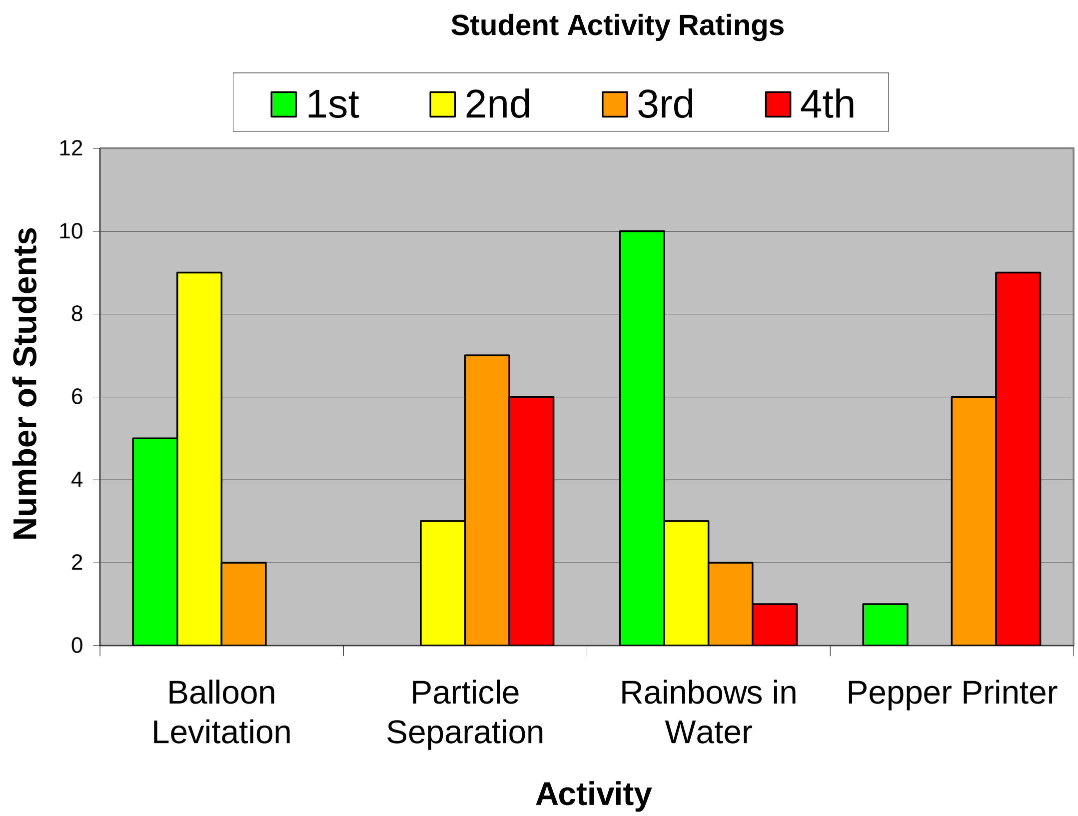

Figure 12: Student responses for the second set of Roxburgh Activities

We used these data, along with our observation of the proceedings above to plan our activity repertoire for our final school, Mount Ridley College. The data from the first day was not very useful as there were only two activities and the Sweat Spot activity did not work because it was too cold. We did note that the students really liked the engineering Heart Valve activity. In addition to the Heart Valve activity, students also liked the Rainbows on Water and the Balloon levitation activity on the second day. Unfortunately we did not get to run our third day at Roxburgh because two school assemblies conflicted with our scheduled times.

On the surveys we also asked the students for their comments on what they would improve about the program. Unfortunately, it appeared that not many of the students took the surveys seriously and the number of useful responses was limited. These responses include:

- “less talk more activities” (Student U, survey, November 12, 2013)
- “more experiments” (Student W, survey, November 19, 2013)
- “more time for activities” (Student F, survey, November 12, 2013)
- “It’s all good bro” (Student A, survey, November 19, 2013)

We struggled with the paradox of adding more experiments while having more time for activities and made changes to the program structure to accommodate. Mount Ridley College’s schedule allowed for 120 minute programs. The program we developed for them comprised four hands-on activities.

We also asked the students for their responses to seven questions designed to gauge the students’ attitude toward science. One of the questions (“I am not interested in science”) was used to determine if the students took the time to read the survey rather than choosing a number and filling in every response for that column. Students that did this were excluded from the data analysis. In addition, due to excursions during our presentations several students were missing one or more surveys. Data from these students were also removed. After this filtering, data from only thirteen of 23 students remained. We then calculated a score to measure the change in ‘science attitude.’ The responses from “I do not like Science” were scored backwards of the other six because it was a negative. The science attitude score is the sum of all seven questions. And the difference is the post-test sum minus the pre-test sum. We then conducted a two-tailed t-test to ascertain whether the change in the ‘science attitude’ score was statistically greater than zero, that is to say: statistically significant. We determined the p-value, and if this was less than .05, we concluded that the change was statistically significant.

While there was a general increase in the ‘science attitude’ score, it was only marginally statistically significant ($p = .063$). Looking at each student’s scores, we found that nine students showed an increase in their science attitude, two showed a decrease, and two remained the same.

We observed that:

- Some students appeared to participate enthusiastically but others did not at all.
- The students did not ask many science-related questions.
- We had the correct number of activities; total program length not too long or too short.
- The surveys were not always taken seriously.
- The students were upset that ‘sweat spot’ did not work.

4.3.3 Mount Ridley College

The program at Mt. Ridley College was our last school in the pilot program. It was divided into four separate sessions for 2 hours each with four different classes. The programs were held on two consecutive days, with two classes each day. After meeting with the science coordinator 2 weeks before the visits, we were told to base the activities on any topic that has been covered in the year nine curriculum that year. Our visit was after their exams, so the teachers were looking for engaging activities to keep the students involved. Since each of the four sessions comprised different classes of students, we were able to create one 2-hour program and implement it four times. This provided us with the opportunity to run the activities that we thought were best without being constrained to certain topics.

We opened the presentation with an introduction to ourselves and Banksia Gardens then prefaced each activity with an explanation. The program we included for this school included four activities. The first activity was the balloon levitation "wow-factor" from our Roxburgh visit. We allowed the students to pair up and try this on their own for a few minutes. The next activity was called "Need a Hand" where students built a prosthetic hand out of common household materials. The one goal of the activity was to make the fingers move. Third, was a quick experiment in which we put nail polish on water and observed the rainbow produced by the resulting thin film interference. Lastly, we had a competition to build a catapult that launched a piece of cardboard furthest using common household materials again. Each of the activities worked well, but they all seemed to have different impact on the students. All of the students were engaged in making the hand and catapult while there were several students not as enthusiastic about the other two activities. We found the balloon levitation to have a more positive impact in the second and third sessions than the others. This may have been due to the activity working slightly better due to weather conditions (not as humid) or just how the students behaved as a class. Students were able to try this activity on their own as well, but not all participated. When the students tried the activity, they were laughing and seemed to enjoy it. The second activity, "Need a Hand", shown in figure 13, appeared to go very well with all sessions. For most students, this was the first time they were able to participate in an engineering project. Most students found this very exciting because they worked on a solution to a real life project and learned how prosthetics work. In the first three sessions, every single student participated actively. The fourth session had a group of students that did not want to participate, but we tried to work around the issue. We tried not to call too much attention to this group so long as they were not distracting other groups. We did little to discipline the students for minor behavioural issues because we were trying to maintain the informal feel of the class period. Ultimately additional teaching staff arrived to keep an eye on things in case they got out of hand, which they did not. Students were excited to share their designs at the end of the activity and learn how they could improve their models.

Figure 13: Mount Ridley College students participating in "Need a Hand"

After "Need a Hand," we moved onto the next activity, which was "Rainbows in Oil." The nice part about this activity is that students were able to take home their rainbow on the black piece of paper. One student in the second session was especially excited to do this experiment because her friend from the first session had shown her the paper at recess between the sessions. We took that comment as evidence that the activity was successful, because it impacted the students enough to talk about it outside the classroom.

Lastly, we conducted another engineering activity, "Catapults," shown in Figure 144. In this activity, students used everyday materials to create a catapult that launched a piece of cardboard furthest. The competition aspect added a new element to the engagement of the activity. Students were eager to have the best design and set a school record and win lollies.

This encouraged students to use the engineering design process and modify their catapults after each time they tested it. In addition to the competitive aspect increasing students' engagement, many students seemed to like the activity because they were able to launch materials, which is not normally allowed in the classroom. The teachers were all enthusiastic about the activity, as well. Some even stated that they were going to use it with their other younger science classes. Because of the verbal and written feedback on this activity, we concluded it was the most successful.

Figure 14: Mount Ridley College students showcasing their winning catapult design

The overall consensus of the students, teachers, and group members was that this program was extremely successful and that the students greatly enjoyed participating in the activities. The students in the first three sessions were very respectful and excited about each activity, and listened to what we had to say. The last session was the most challenging because the students were misbehaving and very energetic and as a result, we had difficulties controlling the class. Besides the few students that were causing issues, the rest of the class appeared to enjoy the activities.

After the first session on the first day, the principal of the school came into the classroom to personally thank us for coming. He exclaimed that he had heard only very positive feedback from the teachers and students of the first session. He asked for our full names and brought in the school camera so that the sessions could be included in their newsletter. Each teacher that participated also greatly appreciated us being there. These statements, as well as the students' comments made us feel as though we really made a difference on these students and changed their mind on science ideas. One student who did not want to participate at all told our group that she normally hates science class because it is mostly taking notes and tests. After the program she came up to us and said she didn't realize science could be so fun and she really appreciated us coming into her classroom. These sessions were extremely gratifying and successful.

In the future, we hope that Banksia Gardens can continue to run programs for students. The teachers exclaimed that they would love Banksia Gardens to come multiple times a year, but especially at the end of the year again.

Once again we asked the students for their favourite activity, and assigned a score as previously described. The difference here is that we had four sessions of identical programming so the scores for these activities are the averages of all four sessions, which is illustrated in Figure 15. From the data, we found that 'catapults' was the most popular activity, followed by the 'Rainbows in water' activity.

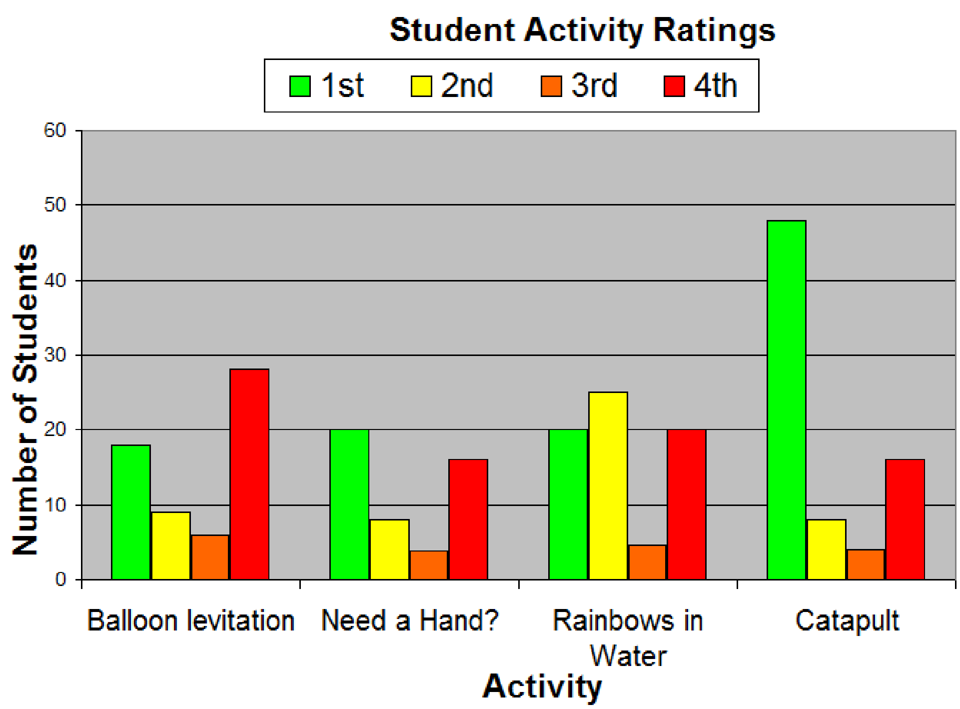

Figure 15: Student responses for the Mount Ridley Activities

Despite a very high non-response rate (56 out of 93 students responding), many students felt that the program did not need to be changed. Eight students responded that they did not want to change anything. More critical students replied that they wanted more activities, slight changes to the activities, and longer times for the catapult activity.

We had a much larger sample size for Mount Ridley compared to Roxburgh; 82 useful student responses. As a result we were able to group responses by several criteria, including student gender, whether students wanted to participate or not, and students' prior attitudes towards science.

Both girls and boys exhibited statistically significant increases in their science attitude score ($t(30) = 2.25$, $p = .03$ for girls, and $t(51) = 3.49$, $p < .001$ for boys). Both students who did not want to participate and those who wanted to participate exhibited statistically significant increases in their science attitude score (respectively $t(13) = 3.78$, $p = .002$, and $t(65) = 3.25$, $p = .002$)). Those who indicated prior to the class that they did not like science exhibited a statistically significant increase in their science attitude score ($t(46) = 3.5$, $p < .001$ but there was no difference for those who had indicated they liked science (Table 7). The scores are a sum of seven questions and thus range from 7-28. This may have been due to the fact that the scores provided by students were already high on the pre-surveys; on the post-surveys, the students could not select much higher scores.

Group	**Average Increase**	**'Science Attitude'**
All Students	1.65	Significant Increase
Girls	2.03	Significant Increase
Boys	1.78	Significant Increase
Those who did not want to participate	3.00	Significant Increase
Those who did want to participate	1.50	Significant Increase
Those who do not like science	2.30	Significant Increase
Those who like science	0.69	Non-Significant Increase

Table 7: Summary by group of the 'Science Attitude' of all Mount Ridley Students

We expected to see this pattern, because these are the students that already liked science before the program, and while we expected them to enjoy the program, there was less room for improvement with their attitudes towards science. The exact reason that the students who liked science did not show a significant increase in their scores cannot be identified with these data and will require further research.

From our observations of the sessions, we saw that many of the students were engaged in the activities. There was only about one student in each group that did not want to participate.

After each session we took time to debrief with the teachers who were present. The teachers agreed that the students were very engaged (L. Enval, S. Smilie, personal communication, December 5, 2013; S. Garth, S. Smilie, personal communication, December 6, 2013). One teacher said, “That was the most I’ve ever seen them engaged in science” (S. Garth, personal communication, December 6, 2013). When asked what they would change, S. Smilie noted there was not enough time to go over ‘big’ concepts (personal communication, December 5, 2013) and G. Hardwick said that the link between the information and the activities could be clearer (personal communication, December 6, 2013).

Some observations across all three schools include that the students seemed most engaged in the engineering activities, (heart valve, need a hand, and catapults). These activities have no set procedure or rules, only a set of materials and problem to solve. These are not like most in-class practicals where students follow a procedure to get to the end result. This gives them a freedom they are not accustomed to and we believe they are more engaged because of it.

There are some limitations to our data collection methods. Even with the large number of students at Mount Ridley College There were very few open response answers taken seriously and many left blank. We were unable to administer all the surveys to the students at Roxburgh due to our last session being cancelled. The types of data we collected were different across the sessions, which made it difficult to find trends. We expected the students’ attitude toward science to increase in the short run because they would be excited about us and the fun they had that day. In the long run though this will probably fade, but we have no way of testing this within the scope of our project.

Chapter 5: Conclusions and Recommendations

We live in a world dependant on technology, and yet in the past twenty years, there has been a decline of science interest in literacy in many developed countries. In Australia specifically, the recent Programme for International Student Assessment (PISA) results show that between 2006 and 2012, there has been “a significant decline in the mean scientific literacy performance for students” and a “significant increase in the proportion of low performers” in Australia (Thomson, 2013). These statistics demonstrate that in spite of many efforts in the formal and informal education sectors, much remains to be done to stem the declining interest and proficiency in science in Australia.

We learned from our literature review and interviews with science educators that hands-on, inquiry-based approaches to teaching science are effective at engaging students. Teachers learn about the effectiveness of hands-on methods during their training, but these methods are often difficult to implement in the classroom. As a result, the Australian government created the national Inspiring Australia initiative to promote science interest in young students. In addition to national efforts, private organisations like CSIRO are also using hands-on presentations for the same goal.

In addition to the larger informal education groups, local community centres such as Banksia Gardens Community Services are making efforts to increase engagement in science in their communities. Banksia Gardens’ efforts are focused on the underprivileged Broadmeadows community, where the disinterest in science is particularly high. In our work creating a pilot program for Banksia Gardens, we have drawn conclusions on the subjects of effective program execution, program content, evaluation methods, the target age group, and requirements for sustainability. On each of these topics, we also offer recommendations for the future development of the *Give Science a Go* program.

5.1 Program Execution

As we learned through the development of our science education pilot program, there are many challenges when working with local schools. There is always a variation in the commitment and response time of the teachers, and a difference in the amount of time each school can give for the program. We recommend that Banksia Gardens tries to identify teachers within schools that are excited and receptive of the new program to help support the development of the program in the future. We also recommend that Banksia Gardens work with science coordinators and principals at the schools to help promote the program and encourage more teachers to participate.

The activities outlined in the Portfolio will require multiple people to facilitate the small groups necessary for each activity within the program. Banksia Gardens currently does not have the resources to send multiple staff members to each class. We recommend that Banksia Gardens use this Portfolio to train the volunteers that they can find to deliver these programs in the local schools.

As seen through our background research on informal science education, we have determined that in order for our science education program to be successful, the students need to be exposed to the science activities over a longer period of time rather than just 1 day of the program. With this in mind, we recommend the ideal format of this science education program would include four 90-minute sessions for each school, spread out throughout the year, with one session per term. This ideal format may not always be feasible, so the facilitators of the program will need to adapt the format and schedule to fit the needs of each school.

As we have seen through our pilot program, students are often most engaged in activities that involve a competitive aspect. As suggested in the previous project conducted at Banksia Gardens, we recommend that Banksia Gardens hold an annual science competition or fair to promote the in-school science education program as well as get students excited about science outside of the classroom.

5.2 Content

The Portfolio covers a wide variety of topics and contains a large number of activities, but we recognize that the school curriculum may change and program facilitators may identify new topics and activities they wish to add. We recommend that Banksia Gardens treat this Portfolio as a living document, being modified as the program develops. This would include adding new activities to the Portfolio, updating the current activities based on teacher, student, and facilitator feedback, and fixing broken URL links to useful resources. A great resource for new science activities, which we took advantage of, is nsdl.org, the National Science Digital Library. It is a large index of activities and other educational resources for teachers. In addition to the hard copy of the Portfolio, we will be supplying Banksia Gardens with a digital copy that can be easily modified, and will also include the templates for adding new activities.

Based on feedback from teachers, we determined that when the program is implemented at the end of the school year, there is much more flexibility in the choice of subject for the program because students have typically finished their tests and covered all the required material. We recommend that Banksia Gardens try to offer its programs during these times in order to give facilitators more freedom to choose activities that are fun and wow the students with science even if they may not fit exactly to the curriculum.

5.3 Evaluation

Evaluation is important to any informal science education program to ensure that the program is effective and is continually revised to better meet the needs of the local schools. We recommend that Banksia Gardens develop more streamlined evaluation tools and protocols that can be used in the school setting. Ideally, the evaluation would include a pre- and post-intervention survey of the students as well as a debriefing interview with the teacher at the end of the session. Due to time and other constraints for each school, Banksia Gardens many need to modify this evaluation. The pre-intervention surveys would be administered 1 or 2 days prior to the first day of the program, to ensure that the facilitator's presence did not affect the results. The first post-intervention survey would be administered at the end of each session, while the teacher would administer the second post-intervention survey 1 week after that particular session. This would help to gauge both engagement and retention of information learned by the students in the sessions. We also recommend that whenever possible, the facilitators use the ideal schedule and format for evaluation (including pre- and post-intervention surveys of students and debriefings with teachers) in order to maximize the quality and quantity of usable data gathered.

Due to the time constraints of this project and the fact that we only conducted two or three sessions at each school in a short period of time, the student surveys used could only measure the engagement of the students in the program, not retention of information. In order to do a complete evaluation of the effectiveness of the program we recommend that retention of information should be included. This could potentially include more learning based questions on the surveys or include an activity at the end of the session that tests how much information the students have retained from the session. An example of this type of activity is a flash card matching game, which is presented as a competition between groups. Each group would match a word to a definition related to the information learned during the session. This would help to gauge if the students learned the information from the session. It would also be helpful to look into more interesting ways to present the surveys to the students, so that they will be more interested in answering all of the questions.

5.4 Age Group

It has been shown that the declining interest in science and maths begins in years 6 and 7. Our program focused on students in years 9 and 10. From our pre- and post-intervention survey data, all our year 9 students who initially disliked science reported enjoying it more. However, several of our contacts believe that the greatest impact could be made on younger students. We recommend that Banksia Gardens considers adapting the program for a younger audience. There appears to be an opportunity to have a greater impact young students' attitude towards science, though more research on the optimum age group may be appropriate before making such a significant change to the program.

5.5 Sustainability

Developing, delivering, evaluating, and maintaining in-school science programs requires institutional commitment, funding, and dedicated volunteers and staff. Accordingly, we recommend that Banksia Gardens develops relationships with local universities to identify student volunteers who may be able to help. These students could help with the development of activities, offering supplies, or delivering the programs on their own, especially since a basic understanding of scientific concepts is required for effective program delivery. The Melbourne University Physics department has expressed interest in partnering with Banksia Gardens for any help needed in these areas. In addition to the universities, many members of the community may also be willing and able to volunteer. Many volunteers who come to the Centre on a daily basis already have a science background. Utilizing these community members as well as university personnel would enhance the abilities of the Banksia Gardens staff to deliver these programs, especially since program delivery is more effective with multiple facilitators to assist in group activities in the classroom.

Teachers who have participated in the program may spread the word, but the program needs additional outreach and advertising if it is to be successful. We recommend that Banksia Gardens use their website to spread the word about the new program they offer. The website would include information about the logistics of the program, as well as potentially using teacher testimonials to support the past success. This would also emphasize how the program can accommodate to the curriculum. With the right publicity and personnel to help, the program should be able to be implemented easily and regularly.

Delivering in-school science programs along the lines of our pilot program can be an expensive proposition, in large part because high quality, hands-on, small group activities demand substantial staff time for preparation, delivery, and evaluation. Our Portfolio will help to reduce the up-front costs of developing the program, and the use of volunteers from the community and local universities can help reduce staffing costs associated with delivery. We recommend that Banksia Gardens look into philanthropic charity organisations that might be interested in promoting an interest in science for additional funding. The Hume City council has been aware of the efforts Banksia Gardens is doing to create this program, so we recommend that Banksia Gardens pursue these and other connections. Any help from local organisations will help promote the program in the Hume City area. We also found that buying program supplies for one class at a time becomes expensive quickly. To cut down on these costs, we recommend that Banksia Gardens seek cash or in-kind donations to develop activity kits for all the activities in the Portfolio. These kits would include all materials and instructions for a given activity, making it easier to gather supplies at the time of implementation. Utilizing volunteers to create these kits would also be beneficial and cut down the overall cost of a particular activity. Through the creation of kits and partnerships with charitable organisations, we believe the program can be sustained effectively in Banksia Gardens Community Services.

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Appendix A: Sponsor Description: Banksia Gardens Community Services

The Banksia Gardens Community Services Center was first built in 1981 in the Banksia Gardens Estate to promote community participation between tenants of the public housing estate[4] and other local residents. The Banksia Estate was built in 1975 in Broadmeadows, an area that desperately needed housing. Broadmeadows is a suburb in the south-east of Hume city (Figure A 1 and Figure A 2). The 150-year-old suburb was originally a farm town, but new settlements were developed after the railroad was built in the area. As the area expanded during the 1950s to 1970s, the demand for public housing increased (Broadmeadows - Hume City Community Profile, 2013).

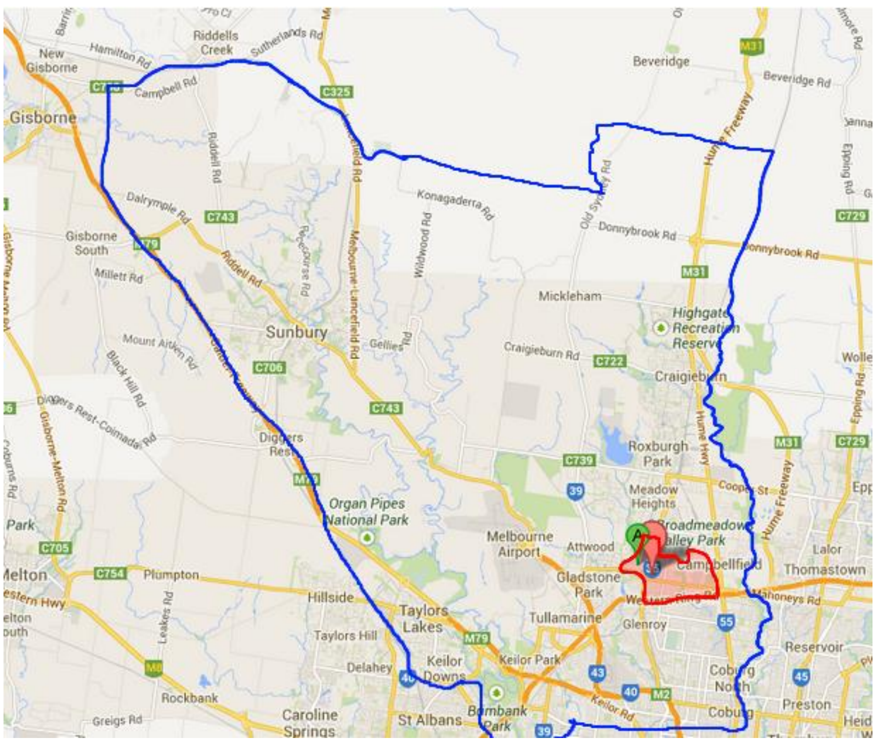

Figure A 1: Hume City outlined in blue, Broadmeadows outlines in red

[4] A public housing estate is equivalent to a public housing development in the United States.

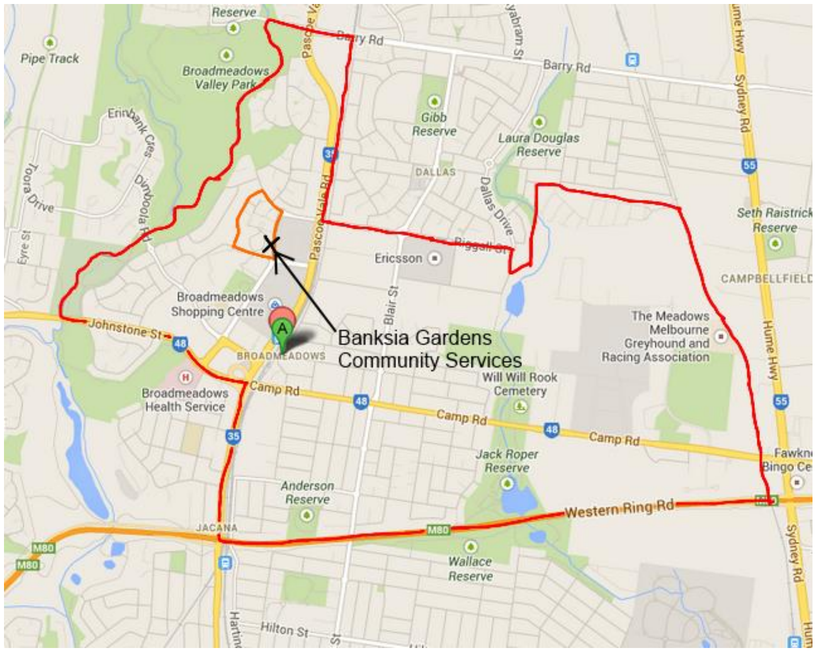

Figure A 2: Broadmeadows in red, Banksia Gardens Estates in Orange (Google Maps, 2013)

The Banksia Gardens public housing estate is one of the most underprivileged areas of Melbourne. The estate houses over 360 residents, 70% of whom are single parents, and 49% of whom were born overseas. As illustrated in Figure A 3, educational attainment is limited and only 25% of the residents completed. Year 12 in 2008 compared with 48.5% of the population of Melbourne as a whole. In addition, 25% of the Banksia Gardens population was unemployed in 2008 compared with only 5.3% in Melbourne as a whole, and incomes are substantially lower (Banksia Gardens Community Connections, 2013).

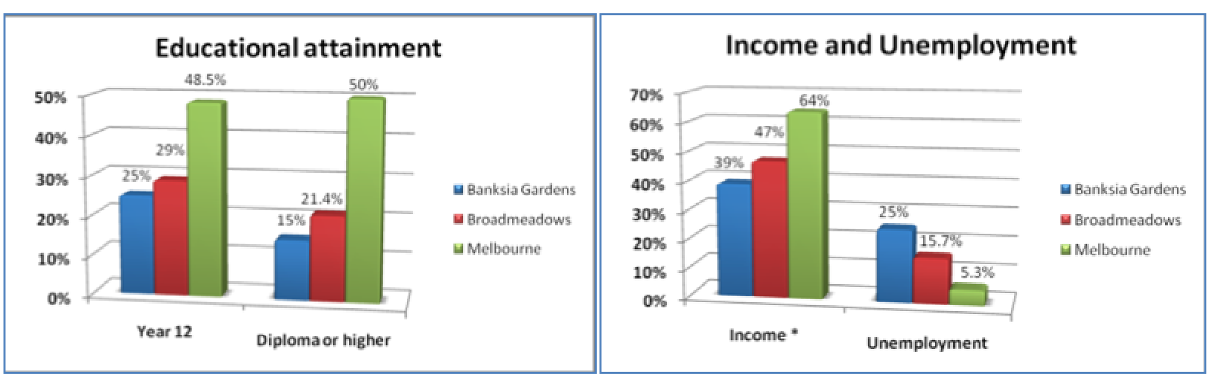

Figure A 3: Educational Attainment and Income and Unemployment in Banksia Garden, Broadmeadows and Melbourne (Banksia Gardens Community Connections, 2013)

The purpose of the community centre was to provide help for single parents, low-income families, and young people in particular. Since its inception, the Center has provided a variety of activities and engaged in extensive community outreach to promote a sense of cohesion and belonging within the community, including health and wellness programs and out-of-school and after-school educational programs. The Center also serves as a meeting place for youth groups and other members of the community.

In the 1980's and 1990's the centre (Figure A 4) unfortunately became a focus for community violence, drugs, and vandalism (Banksia Gardens Community Services, 2013). At the same time, the size of the building was beginning to hamper the growth of the organization so expansion was necessary. In 1993 the Broadmeadows Office of Housing built a new community centre for the Banksia Gardens Estate (Figure A 5) to accommodate the growing demand.

Figure A 4: Vandalism on the original community centre (Banksia Gardens Community Services, 2013)

Figure A 5: Present community centre in Banksia Gardens Estate (Banksia Gardens Community Services, 2013)

The venue can be rented out for different types of occasions with one of Hume's largest halls, seating up to 180 people with room for up to 220 standing persons. The venue is used for events such as large meetings, conferences, and weddings. There are also smaller rooms including classrooms and a computer room that can be rented out for a period of time. The centre is staffed by 22 paid, full and part time employees and also receives help from volunteers to teach and facilitate programs. There is a hierarchy that includes the CEO, managers, project coordinators, tutors, and other general purpose staff. The volunteers help with study groups, grounds keeping, and other academic and community programs.

Since the centre opened in 1993 the staff has been working to provide new and relevant programs and courses to meet the needs of the community. The programs range from science and other educational topics to physical education and are open to all members of the community.

For the science programs offered, the centre started with courses in computers and computer software. These cover introductory to advanced Microsoft Office ® and general knowledge of computers and the internet. There is also one course in environmental sustainability with plans to add additional courses in the future. The newest addition to their repertoire is the "Magic Science Day," created in partnership with WPI students, which is a program offered on school vacations where students can come and learn about science through fun activities and demos (Figure A 6). Various hands-on activities are mixed with "wow-factor" demos and competitions to keep students engaged while teaching them science concepts. These activities and programs are currently only available at the community centre itself but there are plans to incorporate the "Magic Science Day" material into the curricula of local schools.

Figure A 6: Students building toothpick bridges for "Magic Science Day" (Banksia Gardens Community Services, 2013)

In addition to the many science related activities offered at the Banksia Gardens Community Center, the centre offers many other activities to the surrounding community. One type of activity that is offered is the Creative Arts, including theatre and performance, jewellery making and sewing. The centre also offers many options for health and fitness to help "refresh the mind". These include yoga, karate, taekwondo, and low-impact exercise.

Banksia Gardens offers many different types of childcare options, such as the 'Little Bugs' playgroup for children aged zero to five years, as well as assistance in finding a playgroup in the area (Figure A 7). They also offer playgroup training sessions. In addition to actual childcare, Banksia Gardens offers courses at all levels to help people to pursue a career in Child Care Services. Banksia Gardens also offers a variety of Study Group options for older children, designed meet the different learning needs of children.

Figure A 7: "Little Bugs" Playgroup (Banksia Gardens Community Services, 2013)

The centre also holds the Banksia Gardens School Holiday Program for a low price during every school vacation for 2 weeks. The program includes both academic and recreational activities. Some of these activities include bowling, city tours and excursions, dancing, music, sports and fun science experiments.

Our role while working with Banksia Gardens would be to design and implement the pilot of a new science and education program. Starting where the previous two IQP groups left off, we would start by developing educational materials and activities such as displays, program plans, interactive events, and content in other media.

Appendix B: Science Educator Specialist Interview

Interviewee:

Chair Person:

Minute Taker:

Note: The answers to each question are not verbatim. They were in conversation form and are not the exact words of the interviewee.

Is it alright if we quote you in our final report for your answers to these questions?

☐ Yes ☐ No

1. Do you currently see an issue with students being disinterested in science?
2. What are common attributes of students in years 9 and 10?
3. Do you have any methods you commonly use in your classroom to engage the students?
4. Are there are tricks that you believe work best to engage the students?
5. How do you test to see if your programs were successful?
6. Do you have any documents that may be of use for us? Specifically for Australian teaching?

Appendix C: Banksia Gardens Staff Interview

Interviewee:

Chair Person:

Minute Taker:

Note: The answers to each question are not verbatim. They were in conversation form and are not the exact words of the interviewee.

Would you mind if we quoted you in our final report for your answers to these questions?

☐ Yes ☐ No

1. What are your opinions on the past 2 projects that have been done at Banksia Gardens to start the development of this science education program?
2. Can you see the impact from the past 2 projects at Banksia Gardens?
3. What were your initial thoughts when you heard what our project would entail?
4. What do you want our project to accomplish beyond what we are already doing?
5. Why do you think or not think our project is important for Banksia Gardens?

Appendix D: Interview with Science Teacher for Pilot Program

Interviewee:

Chair Person:

Minute Taker:

Note: The answers to each question are not verbatim. They were in conversation form and are not the exact words of the interviewee.

Is it alright if we quote you in our final report for your answers to these questions?

☐ Yes ☐ No

1. What topic is your class currently learning about?
2. How much time are you able to give us to work with your class?
3. Are there any safety concerns we should be aware of when conducting our activities?
4. What is the class dynamic like? Are there any disciplinary issues we should be aware of?
5. How engaged are the students on a normal day?
6. Do the student's work better in certain learning environments? For example, small groups, whole class activities, or a mix?
7. Do you have any questions or additional information for us?

Appendix E: Running Sheet Template

[Insert Activity Name and estimated activity time here]

Estimated Time for Activity:
Recommended Age Range:
Recommended Group Size:
Estimated Price for 25 Student Class:
Activity Subject:

Summary of the Activity:

1. **Background on Activity [Primary Facilitator]**
2. **Distribute Materials to Each Group [All Facilitators]**
   - [5]
   - [6]
   - [6]
   -
3. **Experiment Procedure [Primary Facilitator]**
   1.
4. **Facilitator Questions and Hints [Group Facilitators]**
   •
5. **Discussion/Take Away[Primary Facilitator]**

Recommendations for Implementation

Safety

Graphics for Presentation

Citation

[5] Provided by Banksia

Appendix F: Student Pre-Intervention Survey

First Letter of Surname	How many siblings do you have?	Number of month you were born

Age: ____________________

Year: ___________________

Gender: ☐ Male ☐ Female

Circle your favourite subject:

Maths Science Humanities English

Physical Education Technologies Languages Art

What career would you like to pursue? ____

Do you want to participate in this program? ☐ Yes ☐ No

Do you like science? ☐ Yes ☐ No

Have you participated in an outreach science program before? ☐ Yes ☐ No

In the boxes below, please place an "X" in the box which describes how you feel about each statement

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
I enjoy learning about science				
I enjoy doing science experiments				
I do not like science				
I would like to work in a science field in the future				
Science is important				
I look forward to science class				
I would like to learn more about science				

List 2 things you like about science.

1. ____
2. ____

List 2 things you dislike about science.

1. ____
2. ____

Appendix G: Student First Post-Intervention Survey

First Letter of Surname	How many siblings do you have?	Number of month you were born

Age: ____________________

Year: ___________________

Gender: ☐ Male ☐ Female

Are you glad you participated in this program? ☐ Yes ☐ No

After the program, do you like science more? ☐ Yes ☐ No

Have you participated in an outreach science program before? ☐ Yes ☐ No

Rank the following activities (1 being your favourite and X being you least favourite):

___ (insert program activity)

___ (insert program activity)

___ (insert program activity)

In the boxes below, please place an "X" in the box which describes how you feel about each statement

Statement	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
I enjoy learning about science				
I enjoy doing science experiments				
I do not like science				
I would like to work in a science field in the future				
Science is important				
I look forward to science class				
I would like to learn more about science				

List 3 things you learned today:

1. ______________________________
2. ______________________________
3. ______________________________

List 2 things you would change about today's program to make it more interesting:

1. ______________________________
2. ______________________________

Appendix H: Student Second Post-Intervention Survey

First Letter of Surname	How many siblings do you have?	Number of month you were born

Age: ____________________

Year: ___________________

Gender: ☐ Male ☐ Female

What career would you like to pursue? ____

Are you glad you participated in this program? ☐ Yes ☐ No

After the program, do you like science more? ☐ Yes ☐ No

Have you participated in an outreach science program before? ☐ Yes ☐ No

Rank the following activities (1 being your favourite and X being you least favourite):

___ (insert program activity)

___ (insert program activity)

___ (insert program activity)

In the boxes below, please place an "X" in the box which describes how you feel about each statement

Statement	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
I enjoy learning about science				
I enjoy doing science experiments				
I do not like science				
I would like to work in a science field in the future				
Science is important				
I look forward to science class				
I would like to learn more about science				

List 3 things you learned today:

1. ____
2. ____
3. ____

List 2 things you would change about today's program to make it more interesting:

1. ____
2. ____

Appendix I: Observations

Name of the School: ____

Time of Day: ____

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
Students are engaged in the activity				
Comments:				
Students participating in the activity				
Comments:				
Students asked science related questions				
Comments:				
There were complaints about the activities				
Comments:				
There was unrelated conversation during the activities				
Comments:				

Observations (Continued)

Notes about the logistics of the programs

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
There was enough time for the activities				
Comments:				
The surveys were taken seriously				
Comments:				
The correct materials and amount of materials were brought				
Comments:				
Comments:				
Comments:				

Appendix J: Teacher Post-Interview

Interviewee:

Chair Person:

Minute Taker:

Note: The answers to each question are not verbatim. They were in conversation form and are not the exact words of the interviewee.

Is it alright if we quote you in our final report for your answers to these questions?

☐ Yes ☐ No

6. What is your overall satisfaction with the activities we did?
7. Do you believe that students were engaged?
8. Did the activities help the students understand the key concepts?
9. Were the activities age-appropriate?
10. Did the activities match the curriculum sufficiently?
    a. Does it matter if the material didn't match up exactly?
11. Would you want Banksia Gardens to do similar in-school activities in the future?
    a. Why or why not?
    b. How often?
    c. What topics
12. How could the program be improved?
13. Do you have any other comments or suggestions for us?

Thank you for your time. We enjoyed working with your class!