Using Out-Of-School Partnership to Help Secondary School Students Build Connections between Science Theory and Real-Life Applications

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Abstract

The use of out-of-school partnerships can enhance student learning and motivation in science secondary school education, whilst also helping students to relate concepts taught in class to their applications in real-life. Partnerships are most successful when there are beneficial outcomes for all parties involved. Benefits resulting from secondary school outreach programmes with organisations, scientists, and universities, were investigated. There are many positive outcomes from participating in outreach, an overarching one being an increased interest in science by the student participants, with an impact not only the students themselves, but also on the teachers, universities, and science professions, as student interest can be linked to participation. Science literacy, content knowledge, and skills can also be developed through outreach, as can insight into industry applications of science.

Keywords: *Partnership, Outreach, Science, Out-Of-School Partners, STEM, Professional Development, Secondary Education.*

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Introduction

Successful learning does not only happen within a classroom, so why is it that the dominant location for secondary school education? For many years educational theorists have identified that teaching and learning is not just a case of teachers giving out information and the students absorbing the knowledge. The importance of learning through guided participation in experiences and finding sociocultural relevance in these experiences was identified by Eames and Coll (2012). This idea builds on concepts of learning and is greatly developed by Vygotsky, as well as by foundations laid by other theorists including Dewey, Rogoff, and Piaget (Barker & Buntting, 2016). Using activities and experiences different from the classroom norms could be a way to help the disconnect between the scientific theory students are taught in the classroom and the students' perception of scientific applications in real-life, as identified in Vennix, den Brok & Taconis (2017).

Partnerships between secondary schools and out-of-school science experts, such as Science Centres like the East Coast LAB in Napier (Earthquake Commission [EQC], 2017), are beneficial to all parties involved, thus they should be developed as a reciprocal and collaborative practice (Ngai, Cheung, Ngai, & Chan, 2010). It was also suggested these relationships should be built based on common interests, where all parties involved can combine their skills and resources to accomplish more together, and create something "new and valuable" (Ngai et al., 2010, p. 172). Outreach is one way that the gap between science theory and application in Secondary schools could be bridged (Vennix et al., 2017). The concept of outreach explains that an activity is used to bring information to people, where awareness for the use of science in job fields can be increased through the partnership with organisations, universities, scientists, and research facilities (Vennix et al., 2017).

This article explores the use of out-of-school partnerships and outreach to give New Zealand secondary school students the opportunity to participate in learning experiences that are led by subject experts or are experiences outside of the classroom, in order to build connections to real-life applications of science in STEM (science, technology, engineering, mathematics) fields. It also looks at the impact of these partnerships on the professional development of the secondary school teachers involved. The opportunities looked at for this article are: the use of outreach organisations, out-of-school partnerships with universities, and out-of-school partnerships with scientists.

Partnership with Outreach Organisations

Outreach programmes and Learning Experiences Outside the Classroom (LEOTC) can be used to support secondary students in making connections between the curriculum content taught in the classroom and the practical applications of this in real-life science and industry. There have been four main reasons identified by schools for using such programmes: programme compatibility with the New Zealand Curriculum, their ability to provide hands-on experiences, expert resources and staff, and provide life experiences to the students (Hipkins et al., 2002). Studies have also confirmed that these experiences are most beneficial if they are used to support and enhance classroom science learning, where these experiences can offer valuable and motivational opportunities to students (Hipkins et al., 2002, Vennix et al. 2017).

Programmes offering outreach and LEOTC, can be set-up in many different ways. Hodder (2010) identifies types of outreach through science centres to include: open-ended laboratory experiments, such as science fairs and techniquests, and interactive exhibits with predetermined learning and outcomes. These centres can also be included under the umbrella of LEOTC services, along with museums, zoos, observatories, and galleries, which are informal learning environments that provide experiences complimentary to what the students are learning in the classroom (Hipkins et al., 2002). Other outreach examples include: guest lessons by experts in research, visits to industrial laboratories and other work environments, as well as projects or assignments that are developed with industry professionals that look at work or problems in the company's field (Vennix et al., 2017). The programmes offered by these services can be grouped into three levels: short programmes (the most common), medium/ more intensive programmes, and long-term or extensive programmes (Hipkins et al., 2002). Research into the success of these programmes does not seem to suggest with any clarity that they increase the understanding and motivation of students for science education Hodder (2010).

Hodder (2010) explores the use of science centres in New Zealand and internationally, and claims that there is no clear evidence that these LEOTC centres have positively influenced the popularity of science for students. The article suggests that the intention of these centres was to increase scientific literacy to enable the public to make informed decisions on issues with a scientific basis, as well as a goal to increase enrolments and participation in declining science fields. A study by Otrell-Cass that is discussed in Hipkins et al. (2002) also suggests that evidence to prove success of these programmes is often unclear. This claim was based on the results of their study as they were unable to pin-point whether the source of the learning on a topic was related to the outreach, classroom, or other learning taking place. There was, however, an example in the article that has been seen to benefit what they refer to as exceptional students in science. The CREST (creativity in science and technology) programme, in which students undertook their own research/projects with support from an out-of-school mentor with experience in the appropriate discipline (Hodder, 2010), allowed students to have an understanding of the complexity of real-world issues and how to solve them. The CREST programme also helped students to develop skills in investigative inquiry, and build scientific knowledge that extends further than the school science curriculum (Hodder, 2010). These skills have all been deemed as important for student success in science, because they cover important aspects of the nature of science (Gluckman, 2011). This programme was also beneficial for the school teachers involved, because they were able to develop contacts with experts within science fields, and extend their knowledge and skills in science, especially for teaching investigation (Hodder, 2010). Research by Thomas (2012) and Vennix et al. (2017) suggests that there are considerable benefits to using outreach programmes to promote the understanding of science disciplines at a secondary school level. The benefits were not only for the school students but also for the secondary school teachers and the service provider of the outreach. Examples of benefits for students are that science content knowledge can increase, as can the use and understanding of technology (Thomas, 2012). The motivation of the student to study science can also increase (Thomas, 2012), which is beneficial to not only the students, but their teachers, outreach providers, and science industries, because motivation is linked to student success in the area. In the study carried out in Thomas (2012), the results showed that there was a significant increase in knowledge after the outreach laboratory activity, and that the level of acquired knowledge at the end was the same regardless of the amount of preparation and background knowledge the students had prior to the programme. This second finding is interesting as it is contradictory to statements from Hipkins et al. (2002), where it is suggested that in order for successful learning on an outreach trip there needs to be scaffolding of the experience in the classroom as well.

Vennix et al. (2017), explores the use of STEM outreach to motivate secondary school science students, emphasise connection between class knowledge and the outside world, and teach important skills for the work force. These are referred to as 21st century skills and include competencies like flexibility, team work, communication, and problem solving (Vennix et al., 2017). The article suggests that long-term problem based activities, and hearing scientists' perspectives were the most positive outreach experiences for students. Evidence from the study indicated that both the students and teachers found the outreach experience very positive; however, teachers often rated the sessions more highly than students. Three were aspects identified for a successful outreach programme were that students need: autonomy (to feel that they have a say in doing the activity), the relevant skills, and be able to establish relationships with the other people involved in the outreach. The study also showed that short term and lecture based activities were often similar to classroom practice and were not as successful as outreach, which was vastly different from what students did in their normal class (Vennix et al., 2017). The teachers in this study gained from outreach experiences too, where they could explore new contexts and ideas for how to relate the science curriculum to the science work force.

Partnership with Scientists

Organising opportunities for high-school students and scientists to engage in conversation, is one way for students to learn about what people with jobs in science fields actually do, and relate this to what they may be learning in a science classes. Otrel-Cass, Campbell, and Wilson, (2012), suggest that there is a trend both within New Zealand and internationally that school-aged children and teens decide early on if they think they are

capable of participating in science, and as a result many students decide not to have science as part of their formal secondary school education. It has been argued that because of this, connection between science and society needs to be made to empower students to understand socioscientific issues (Otrel-Cass et al., 2012).

Café Scientifique events are one way in which partnership between scientists and secondary schools can be used to enhance interest and engagement in science fields. Café Scientifique for teens, and Junior Café Scientifique are examples of informal settings where students and scientists can talk together about science, current science issues, and the implications for people's lives (Otrel-Cass et al., 2012). Having science related conversations accessible to students, and other members of the public is important for building scientific literacy and understanding, in order for citizens to make informed decisions on science related topics. One of the successes of these conversations is that due to the informal and social arrangement, the participants can often have their questions answered (Mayhew & Hall, 2012), while another is that trust for the scientists can be developed (Otrel-Cass et al., 2012).

Otrel-Cass et al (2012), completed a small case study in two New Zealand secondary schools which adopted Café Scientifique style events organised by students at the schools. The findings suggested that the success of the Cafés depended on the atmosphere of each event, where smaller more relaxed environments that were different from the classrooms were better than larger events where the discussions tended to reflect more of a lecture-style. The Junior Cafés allowed for students to explore science ideas without the pressure of assessment, with students having ownership of the events being crucial to their success.

The Café Scientifique high-school programme looked at by Mayhew and Hall (2012), found benefits of running a teenage programme for both the students and the scientists involved. These benefits included increasing science literacy and awareness amongst the teens, as well as developing realistic perceptions of what scientists do, and the complexities and motivations that might influence them. The latter may help teens to think more critically about and evaluate the information that they see. Effective communication by the scientists to the teenagers was a key focus of the Mayhew and Hall research, with the initial scientific literacy of the teens reflecting that of general populations. This café programme identified key skills for the scientists when presenting to public, including how to know your audience, and some scientists also noted the experience was helpful for gathering information for their own research.

Partnership with Universities

Out-of-school partnerships between secondary schools and universities can be used in many ways to harness a connection between the sciences taught in class to the applications they have in various professions. The format of these partnerships can result in benefits for all parties involved, from the secondary school pupil and teachers, to the university faculty and their students. Partnerships with universities can be used to give secondary school students a taster of university life (Smith, Kindall, Carter, & Beachner, 2016). It can expose them to professions and fields that are offered at higher/ tertiary educational facilities, and can build interest and motivation of the students which may expand the diversity within sciences fields.

There have been many studies into university-secondary school partnerships being used to support interest in STEM subject areas. A reason these partnerships may be common is that often teacher education programmes do not prepare preservice teachers to apply technological and pedagogical content knowledge (TPACK) in their classes (Osler II, Bull, & Eaton, 2012), thus support from experts to apply this in the secondary classroom could be beneficial. Partnerships can be used to develop students' knowledge in the areas lacking, as well as having the potential to support professional development of secondary school science teachers in these areas. Research carried out by Osler II et al. (2012), and Habash and Suurtamm (2010), are examples of how partnerships between universities and secondary school science departments may work, as well as what the results of such partnerships may be.

The *Learning laboratory initiative partnership* between North Carolina Central University and a local school is an example of using the expertise and resources available at a university (Osler II et al, 2012). This gave secondary school students the opportunity to use current and new technologies related to STEM subjects, as well as the opportunity for secondary school teachers, to develop skills and content knowledge in STEM areas (Osler II et al, 2012). The aim for this partnership is to use the technologies to provide a positive impact on secondary school student performance in STEM subjects. An engineering and mechatronics outreach programme through the University of Ottawa, in Canada, is another example of a partnership working to improve secondary school students understanding and awareness of STEM subjects, in order to connect the mathematics and science taught in schools to real-life applications in the field of engineering (Habash & Suurtamm, 2010). It was identified in this article that ways in which to strengthen career choices in STEM fields, such as engineering, included: influence of parents, providing related career information, and through high school science and mathematics courses. With these in mind the programme works to target a wide range of students to increase the pool of potential students interested in careers in the field.

This particular programme involved outreach in the form of information sessions and web-based resources, along with having the students from the universities engineering course present their engineering projects to the high school students. These presentations helped develop interest amongst high school pupils but also helped the engineering students to explain engineering concepts in a meaningful way for non-experts. Feedback was collected by a survey each year of the study, with 97% of the high school students saying that listening to the presentations gave them a better understanding of applications of mathematics and science in real-life contexts, and 72% said that the presentations enhanced their interest in science and mathematics (Habash & Suurtamm, 2010). The results of this study showed that outreach was an effective tool for encouraging the connection between high school mathematics and science to real world applications, and for building understanding of what the professional fields are that use these applications. The study also highlights the significant help outreach activities can offer to support high school teachers to meet the educational challenges for their students (Habash & Suurtamm, 2010).

Conclusion

Although studies may not be able to prove that outreach activities are solely responsible for increases in knowledge and motivation in science fields, there is strong evidence that students involved in outreach have interest, motivation, and experience in science concepts and their uses in real-life and industry (Habash & Suurtamm, 2010). Secondary school partnerships with out-of-school experts can enhance the science education that students receive as well as provide learning experiences for secondary teachers and other parties (e.g. university students, science industry). These experts can belong to myriad of places including organisations, businesses, universities and other research institutes, and in order for the partnership to be sustainable these experts must also gain something from the experience.

Partnerships with specialised outreach organisations can benefit secondary school students and teachers by improving pupils' abilities in inquiry, scientific literacy, and 21st century skills, as well as increasing their content knowledge and understanding of real world issues. Teachers can extended their knowledge and skills, especially for scientific inquiry and relating science to the work force. Partnerships with universities also enhanced these aspects, along with sometimes being used as a teaching tool for the university students as well. Outreach can help to expand diversity within science professions by giving all students a taster. Platforms like a Café Scientifique allow scientists to practice communicating science ideas with non-experts while giving the students insight into what the scientists did, current scientific issues, and some opinions on them.

Although there is still opportunity for research into many areas around out-of-school partnerships for secondary science education, there are many studies to support using them to enhance students' science knowledge and their ability to connect this with real-life applications.

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