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Powerful partnership: An exploration of the benefits of school and industry partnerships for STEM education

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POWERFUL PARTNERSHIP: AN EXPLORATION OF THE BENEFITS OF SCHOOL AND INDUSTRY PARTNERSHIPS FOR STEM EDUCATION

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Abstract

This article is based on the findings from a Master of Education dissertation, which explored the partnership between a junior school (Year 7–10) in New Zealand and VineLife Limited—a technology company based in Auckland. In this partnership, the students completed a design sprint, including a series of activities that required them to apply design thinking to a specific problem: investigating how to best use a sensor to scan trees within a forest for diseases. This article explores the benefits of such school–industry partnerships and shares insights gained from the research, including the benefits of exploring authentic problems, engaging with external audiences and encouraging student agency and critical thinking. Assertions are made about the need for a person to liaise between the school and industry to best enable Science, Technology, Engineering and Mathematics (STEM) based learning in schools.

Introduction

This article focuses on the benefits of school–industry partnerships, based on the literature and the findings from my Master of Education research, which explored the ways that authentic experiences can support Science, Technology, Engineering and Mathematics (STEM) learning in schools. STEM refers to learning situations or activities that require students to use knowledge and skills from multiple disciplines (Honey et al., 2014). By having students participate in an authentic STEM scenario, they can benefit from the practical experience in a number of ways. For the purposes of this article, the focus is on learning pertaining to the New Zealand Technology curriculum (Ministry of Education, 2017) where "design is characterised by innovation and adaptation. It is informed by critical and creative thinking and specific design processes" (p. 1). Critical and creative thinking can be more effectively fostered through the provision of authentic scenarios and by exposing students to a design process in a practical context.

This research resulted because in early 2019, an industry Chief Executive Officer shared how his company was working on a solution that scanned trees for pathogens. During the conversation I suggested having my students explore the problem. As a result, six students from Ormiston Junior College worked together to ideate and develop innovative solutions to scan trees for various plant pathogens—without the need for humans. This was a problem worthy of consideration, as the method at the time was for a person to carry a sensor and manually scan each individual tree. This was proving both costly and time-consuming for the company.

When Mark, an Industry Chief Executive Officer, shared his technological problem with me and described how they were creating sensors to replace the current method being used, it was clear that sensor technology was still being developed and had commercial sensitivity. As a consequence, students were not told about the technical features of the sensors beyond what was required for their design sprint. A design sprint is rapid-paced design thinking, aimed to achieve viable human-centred solutions. It involves the creation of prototyping innovations in a fast-paced environment (Thomas & Shin, 2016). Design sprints are commonly used in professional settings, but they are especially used by technology companies and Information Technology (IT) companies (Dorst, 2011). They can strongly align with approaches used for STEM learning, and particularly in technology education where there is a need to develop innovative solutions. The New Zealand Curriculum (MOE, 2007, p. 32) defines technology as an intervention by design, and design sprints provide a framework to enable this intervention.

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The project

The project began with a video conference with Mark, to learn about the technical specifications of sensors under development—such as size, dimensions and weight. Over the course of two school days, the students worked through a design sprint to develop solutions for how to use the sensor to scan trees in a large forest. These sessions were videotaped and the students completed both pre and post surveys, interviews with the researcher and a daily journal to record their work. The first section of this article describes the lead-up to the project and the context in which it takes place, from my perspective as both a teacher and researcher. This is intended to provide insight on the process that can be used by STEM educators when working with experts from Industry. The following sections describe the context and nature of the research.

Background to the research

The research project reported upon here was the result of more than five years of personal growth in teaching, focused on problem-based learning (PBL) and STEM-based instruction within a New Zealand context. It began with my involvement in several community citizen-science projects that were funded by the Nation of Curious Minds Initiative. This programme was created to foster collaboration between schools and scientists, as the government was informed of the many benefits obtained from such partnerships (Gluckman, 2011; Ministry of Business, Innovation & Employment (MBIE), 2014). Several of the projects I facilitated resulted in tangible outcomes. Notably, in 2013, I ran a project with Year 6 students from Rongomai Primary School where we investigated and discovered a new fungus, Candida Rongomai-Pounamu, which we named. The students' discovery was published in the scientific journal, *Fungal Planet* (Padamsee et al., 2017). The fungus project was the first time I began to fully appreciate the capabilities of students to meaningfully contribute to, and work on, authentic science projects. Over the following years, I have also been fortunate enough to work with students in making technological products used by professionals—such as creating a 3D-printed device to test waterways for plant pathogens. The development of this project was also published in a scientific journal (Bellgard, 2017).

From this point, I continued to foster partnerships, collaborating on projects with an increasingly diverse group of industrial leaders and researchers. This benefited my teaching practice and developed students' thinking through exposure to authentic learning experiences and as a means to introduce them to a range of possible STEM careers. A qualitative analysis of 45 journal articles by Rule (2006) found four benefits of authentic learning in science and STEM education, including:

1. Activity that involves real-world problems and mimics the work of professionals, particularly when the activity involves the presentation of findings to audiences beyond the classroom.
2. Use of open-ended inquiry, thinking skills and metacognition.
3. Engagement in discourse and social learning within a community of learners.
4. Self-directed learning opportunities in project work.

School–industry partnerships present opportunities to extend and accelerate the learning within a school, by providing learning experiences that are more authentic and personalised (Penuel et al., 2016). There are similarities between the technological processes used by the professional organisations and schools. For example, design-thinking tools, such as rapid ideation and creating experiences from multiple perspectives, are used to empathise and make connections with the end user, whether that is the consumer or customer. Professional organisations are increasingly aware of the need to connect with children and youth in the development of new products and services, as young people are an ever-increasing segment of the consumer market (Durl et al., 2017). Such thinking led to the development of my research question, which investigated the benefits of a school–industry partnership, and asked:

> How can a small group of 6–10 students, aged between 11–4 years, work with an industry partner to run a design sprint to:
>
> (i) Create a solution that addresses an identified need?
>
> (ii) Identify the benefits of an industry–school partnership?

Industry–school partnerships

New Zealand schools are increasingly looking outward to the local community to enhance student learning through informal and formal partnerships with external organisations (Lee & Abdulghani, 2015). Educational partnerships may be understood as relationships between or among educational or resource providers, and learners, who may variously be individuals, organisations or collectives (Bagnall, 2007). Within New Zealand, the national strategic science plan, as represented here through a Nation of Curious Minds (MBIE, 2014), provides funding to support a vision of strategic planning for schools and community groups to partner with industry and science organisations—with the goal of investigating key scientific and technology issues. This strategy was developed as MBIE determined that science literacy is fundamentally important to the future of New Zealand and its citizens, and it aspired to develop this through strengthening the links between scientists, schools and communities (MBIE, 2014).

The benefits of industry–school partnerships

Students' confidence, attitudes, career and educational aspirations improve when they participate in authentic projects in a 'real-world' context and through working with an industry partner (The Australian Industry Group, 2017; Traill et al., 2015; Ziegler, 2001). In addition, such experiences can lead to an increase in school leadership capacity and enhancement of educational experiences for students (Abowitz, 2000; Ziegler, 2001). Research by Gross et al. (2015), investigating partnerships between school staff and industry, identified that building relationships with a common purpose is the most valued aspect of partnerships for industry. For schools, however, the most valued aspect was enhanced learning for their students. Such benefits lead to the creation of authentic learning experiences for students and greatly increase their motivation and agency to learn (Radinsky et al., 2010).

School–industry partnerships have the potential to extend and accelerate the learning within a school by providing experiences that are more authentic and personalised in nature (Penuel et al., 2016). By creating learning scenarios with unknown solutions, students have the freedom to choose the materials they use, design and build, and engage with interactive experiences in ways that enable them to take charge of their learning (Falk & Dierking, 2000). By creating and fostering relationships in ways that are atypical for a school environment, partnerships hold the *power* to create a more equitable education system—by increasing the quality of learning experiences for both teachers and students, including those who might not otherwise have these types of experiences (Penuel et al., 2016). This is pertinent because there is a mismatch between the STEM skills young people have when they leave the schooling sector, compared to what the labour market actually demands (Carberry et al., 2015). Industry-school partnerships could increase communication and connections to better align curriculum and teaching to meet the needs of employers whilst also preparing students to be active and meaningful participants in both their future employment and society (The Australian Industry Group, 2017).

There is an increasing body of research (e.g., Lee & Abdulghani, 2015; Bagnall, 2007; Cardini, 2006; Davies & Hentschke, 2005) supporting school–industry partnerships to promote authentic experiences, and specifically STEM learning, because industry groups have the resources, expertise and experience required that schools typically do not.

The challenges of industry–school partnerships

While Radinsky et al's. (2010) research showed partnerships could create mutually beneficial relationships, they also revealed "partnership brought out conflicts in cultural values between school and corporate communities" (p. 424). Tensions of this nature can result in conflict around expected timeframes to complete a project, or lack of empathy for the needs of the other partner. Resourcing is one of the most commonly cited challenges as well as the possible deterioration of the relationship between the school and industry partner (Abowitz, 2000). Working with schools, while viewed by the science community as worthwhile, places considerable demands on scientists' time and the funding available to them (Bolstad et al., 2013). Due to the inherent differences between schools and businesses, it is important to have a person or persons involved in the partnership who understands both perspectives and is able to communicate with all parties and support their partnership. This person can be referred to as a boundary broker.

Boundary brokers, intermediaries and cultivators

Boundary brokers can be referred to as intermediaries and/or cultivators. In this article, I use the term boundary broker. However, the role of a boundary broker goes beyond the simple connection of two groups or the ability to foster a successful relationship whilst navigating the complexities within the core features of each organisation—such as management structure, funding, working schedules and organisational priorities and interests. The need for this role has been identified within the New Zealand science community (Bolstad et al., 2013). Brokers are needed as they are able to mediate and liaise between the worlds of science or technology and education to connect schools with relevant professional organisations in industry. For example, SouthSci facilitators play the role of boundary broker for the national Curious Minds funding scheme within the Auckland area. They support schools, scientists and communities to connect and run a joint science project. Their website states, "We could work with you to design a research project. You could then be paired up to work with local scientists to analyse the samples in a laboratory" (COMET Auckland, 2019).

Given the differences between schools and industry, there is benefit in both groups working with an individual who can align the vision, aspirations and practices of both groups so that a school–industry partnership results in the best outcomes possible for schools—that being authentic learning experiences. Equally, industry organisations can offer a community service that aligns to their company vision and ethos.

Theoretical framework

For this research, I focused on a small group of eight students (4 boys and 4 girls) doing a design sprint, to allow me to monitor student thinking and actions, and with a view to better understand the benefits of students working alongside industry (David & Sutton, 2011). The participants were working within a programme called the Accelerator. I invited students within the Accelerator programme to participate in the research study as participants. To gain rich data, I investigated my research question through a mixed-method approach using a combination of interviews, student reflections, written student questioning and observations within one design sprint that lasted two days.

A mixed-method approach allowed for multiple data collection instruments to be used in combination to gain a breadth and depth of information that could be used to paint a rich picture, reduce inconsistencies and increase validity (Mutch, 2013). This study used thematic analysis for systematically analysing, organising and offering insights into patterns of meaning (themes) across a data set (Braun & Clarke, 2012). Thematic analysis allows for flexibility, which is especially useful in mixed-method approaches (Braun & Clarke, 2012) to allow a researcher to identify patterns in the data that arise during the course of the activities, and to afford opportunities to investigate further and in more detail, through follow-up questions and interviews.

Ethics

This research study was approved by the University of Waikato Faculty of Education Ethics Committee. All participants were made aware that they could withdraw at any time without any consequences and could do so by contacting the researcher or alternatively either the school's leadership team or project supervisor. All parties involved were given written information on the details of this study, contact information, participated in an information session and had the opportunity to ask questions, and afterwards they each provided signed consent.

Findings and discussion

On the first day of the design sprint, the students each created an individual digital reflective journal within a shared Google Document (which is a shared online file) so that they could record their thoughts and reflections with me. This allowed us to access, record and modify the documents simultaneously. The students' first entry was to respond to my prompt, where I asked them to make a prediction of what they thought would take place in the upcoming design sprint. One student commented in their journal:

> I think that today, this team and I are obviously doing a design sprint. So we'll go through the process [of design thinking], for example empathising with the user, using the perspective of the land, the environment, and the people that we are designing our product for.

This comment revealed the student was aware of the concept of sustainability or a need to incorporate the perspective of the environment as well as the people of the land into any [local] solution. The students were then scheduled to Skype with Mark to get the design brief and its technical specifications. Beforehand, the students and I spent approximately 30 minutes discussing questions needed to design a suitable outcome. These questions focused on:

- the height of the trees,
- the ground surface,
- how the sensors scanned the tree,
- what disease we were looking for,
- the distance between the trees.

This meeting highlighted the need for a boundary broker within the project, as I had to spend significant time preparing the students to be able to identify the information they would need for the design sprint and how they might best communicate this to Mark. The students needed to ask relevant and clarifying questions of Mark, and then discuss this information as a group in order to develop shared understandings to apply this knowledge to problem-solve the challenges of preventing the spread of disease and efficiently scanning the trees. This type of thinking directly relates to the Nature of Science Achievement Objective within the *New Zealand Curriculum*—Investigating in Science, which states, "Build on prior experiences, working together to share and examine their own and others' knowledge" (Ministry of Education, 2007, p. 6). Some examples of questions that provided additional data (from the video) included:

Q What type of trees, how many and their size?

A It's the specific circumference that requires scanning, so the tree type does not matter.

Q How close do the sensors have to be to the tree to scan?

A The sensors need to stay at a steady height and rotate around the entire circumference of the tree at an ideal height of 65 cm high and distance of 25 cm from the tree trunk.

Q What season/weather are the trees scanned?

A Summer or when the weather is ideal for scanning.

One student described the meeting in their journal as follows: "We Skyped with our expert, and asked him a lot of questions. We also looked at the environment and how a solution could create more problems, like spreading diseases (such as Kauri dieback) …"

After the Skype meeting the students had a group discussion. This led to unanimous student agreement to focus on a *flying solution* to the brief and to the students researching and ideating possible flying products. From here, the students underwent a series of activities to brainstorm ideas and then prototype or test them. Because we did not have access to drones or blimps, the students instead acted out and built a mock forest with chairs to simulate the process. This was an example of what the New Zealand Technology Curriculum (MOE, 2017) calls Technological Knowledge, through technological modelling. Technological modelling is defined as "understanding how different forms of functional modelling are used to explore possibilities and to justify decision making and how prototyping can be used to justify refinement of technological outcomes" (p. 7).

At the end of the second day, both groups had generated design ideas that used drones and blimps to carry the sensors as they moved through the rows of trees. Each group believed several devices should be used to scan the trees in unison, with the benefit of using their location (in relation to each other) as a reference point as well as using their collective GPS positions for guidance. A student pointed out that "… the drones will also bother animals by invading their space and the noise they create could bother them, but it would be better than the other options, which can do much more damage". This statement revealed that this student could apply the key competency of *thinking* (MOE, 2007), in order to look at the problem from multiple perspectives, such as the environment and the animals within that environment. The aim was to produce the best possible solution for their key stakeholder, which is key to students demonstrating understanding of the Technological Practice strand. In Level Four of this strand, the component of Brief Development requires students to use the stakeholder's brief and feedback into their solution. As part of this project, students gained knowledge and experience to appreciate that in authentic contexts there is rarely a perfect solution and often compromises have to be made between competing needs—this is pertinent lifelong learning.

The students identified two ways to scan the trees without touching the ground, and all involved flying. In one student's follow-up interview questions, he was asked to give future teachers design-sprint advice and he said, "Make sure to use it [design thinking] correctly. For example, don't assume the problem and solution for it before going through with everything [all the phases]." This revealed the student gained a good understanding of the subtle difference between empathising with the stakeholders and defining the features of the solution through the design sprint. He was aware to be careful not to try to solve just the most obvious problem, in this case scanning the tree, but to make sure to fully understand the problem and all the surrounding factors (such as how it might affect the environment) before seeking a solution. This is because a solution can result in creating a new problem; for example, the negative results of introducing animals as biological control, such as possums in New Zealand.

At the conclusion of the two-day design sprint, the students had developed two innovative solutions to the industry brief—one using a blimp and the other using drones to scan trees (see Figure 1).

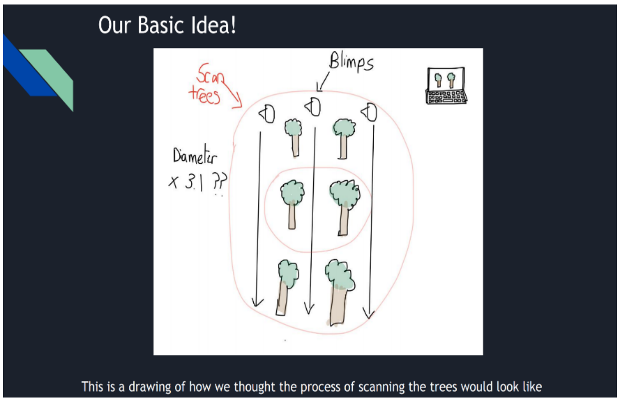

Figure 1: Blimp design.

Solutions included the same unique feature of mesh networking for improved data security and possibilities of combining several devices together in order for increased speed and accuracy of scanning trees—neither of which had been previously identified by Vinelife Limited. All the students agreed that the drone was the best idea because it was the most feasible solution to the given challenge of scanning trees with sensors to identify diseases. Through their research they learnt that using drones is already feasible and realistic, as there are drones that can currently hold the weight of a 2.5 kg sensor. The only obstacle is that the type of drones needed to hold the 2.5 kg sensor cost between $25,000–$50,000. The students' idea of using a mesh network, a portable home base as well as several drones together to reduce scanning time, was both innovative and realistic and the CEO of VineLife Limited agreed these concepts had the potential to be used or adapted.

In the follow-up interviews, all of the students reported increased confidence in going through a design sprint and the desire to participate in more at school. This demonstrated that authentic learning experiences can increase a student's motivation and agency to learn. The industry scenario clearly allowed for the benefits of working on an authentic problem, with unknown solutions, which allowed the students the freedom to pick and choose the materials they engaged with, to design and explore solutions in ways that enabled them to take charge of their learning. They chose to act and simulate the scenario, something they are familiar with in school. An authentic industry problem created an opportunity for the students to mimic skills that the labour market requires.

Implications for school-industry partnerships

It is widely accepted internationally that STEM education, a STEM literate population and STEM careers are vital for the development of a nation (Gluckman, 2011). The current literature reveals school–industry partnerships provide a wide array of STEM learning opportunities, experiences and benefits for the students involved. This includes exploring authentic problems, engaging with external audiences and encouraging student agency and critical thinking. These benefits arise from allowing students to access technology, expertise and authentic problems not typically found within educational settings.

The results from this study are consistent with the current literature on school–industry partnerships. By providing students with an industry problem, it created an authentic learning scenario with unknown solutions. Problems with unknown solutions have been shown to increase students' critical thinking skills and metacognition. This is because it gives the students the freedom to choose how to engage with, design and develop interactive experiences in ways that enable them to take charge of their own learning. This self-regulation, or managing of one's own motivation towards learning, when taught to students through problem solving, is one of the 'High Impact Teaching Strategies' recommended by John Hattie (Department of Education & Training, Victoria, 2017). Critical thinking skills are highlighted in this study, as the students had to interact with the company CEO to clarify, identify and communicate the technical requirements of the given problem in order to design a suitable solution. This demonstrated how authentic learning scenarios provide the opportunity for students to apply their ability to analyse, build knowledge and communicate their ideas.

Critical thinking and problem-solving skills directly relate to the Technology Strand and Scientific Capabilities within the *New Zealand Curriculum*. In addition, communicating to an audience that extends beyond the classroom, the students experienced empathising with the user's needs to then align these needs to the technical requirements of the design brief. When reflecting on their project, they identified this experience as increasing their motivation and agency to learn as well as their desire to participate in future design sprints.

While the study was small in size and short in length, it provided clear insights into the benefits and the types of learning experiences that can arise from partnerships between schools and industry. School–industry partnerships appear to be a significant resource to develop students' STEM abilities and provide learning experiences and exposure to STEM careers, all of which are important to the development of a STEM literate society.

Throughout the process, the importance of a boundary broker, a liaison between the school and industry, was evident at every stage of the project. The boundary broker was most crucial during the development of a relationship and trust between the school and industry that led to the opportunity to work towards a real industry problem. Throughout the design sprint, it was the teacher's guidance, as boundary broker, and continuous clarification of the task(s) that supported the students to reach a successful outcome. Going forward, further research into how to develop boundary brokers and support within schools would be a logical next step towards developing powerful industry–school partnerships, as would an investigation of the types of problems and scenarios that provide the best learning for students so that industry can identify these opportunities. It's clear there is ample evidence to support the creation of school-industry partnerships to support the goal of creating a STEM literate population.

The next steps in research are to investigate how schools can best develop the capabilities, relationships and boundary brokers in order to develop and maintain powerful school–industry partnerships. These partnerships should be supported and researched further as clearly there is a tangible benefit for the students, school and entire nation.

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