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THE POTENTIAL OF INVOLVING COMMUNITIES TO ENHANCE STEM EDUCATION

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Abstract

By engaging students in everyday issues and events, STEM education can contribute to the development of citizens who are equipped to make the world a better place. However, students' STEM learning with this focus requires teachers to identify age and context appropriate issues. Student investigation of local issues and events can be motivating for students. Their learning can benefit from involvement with community members who input their knowledge and ideas. Students can contribute ideas and actions to the community, especially when there is a two-way exchange of information from the community to students and students to the community. In this paper we illustrate these ideas with examples from Australian and New Zealand classrooms.

Keywords

STEM; community involvement; motivation.

Introduction

Science, technology, engineering and mathematics in various combinations and with varied priority at different times are integrally involved in understanding and addressing many of the challenges and opportunities we face as individuals and societies. STEM education as an interdisciplinary approach allows students to become involved in understanding and seeking solutions to problems set in real-world contexts (Bybee, 2010; Hom, 2014). Hence, the rationale for STEM education extends beyond economic benefits to the development of citizens who are equipped to make the world a better place: to enhance our environment and way of life, and to address issues of social justice. We align ourselves with Bybee (2010) when he points out that the personal, community or global issue addressed, whether a primarily environmental, economic or social one, must be age and context appropriate. We also concur that as students explore and come to understand an issue, they need to be supported to 'reach out' to the different STEM disciplines and apply the knowledge and skills they develop to the issue at hand. Given the goal is to set STEM teaching and learning in authentic contexts, students' STEM learning can also benefit from their engagement with the community. Ideally, there is a two-way exchange of information—from the community to students and students to the community (Mildenhall, 2021; Smith et al., 2018). In this case, students have expansive opportunities to develop their STEM knowledge and understandings and their capacities for communication, collaboration, critical thinking and creativity (Berry et al., in press). In this paper we outline some examples of STEM learning in New Zealand and Australian classrooms that illustrate some of the benefits that can accrue from community engagement.

The role of community involvement

Community involvement in education is not new. It can be linked with Dewey (1946) who proposed it is a central component in education that plays a role in transforming society. More recently, there has been a move to consider education as an ecosystem composed of stakeholders and contributors with this ecosystem, including businesses and organisations such as museums, community groups, as well as family and whānau (Buntting et al., 2017; Falk et al., 2015; OECD, 2018; Rennie, 2015). In relation to science education, Falk et al. (2015) point out, "… the 'beneficiaries' of the system include the learners of all ages, not only children but adults and multigenerational groups such as families as well"

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(p. 147). Researching in Australia, Rennie (2006) notes that within the community there are a number of people, groups and organisations that can, with support, make an active and valuable contribution to students' school science learning. She provides examples of how students' science inquiries can contribute insights that initiate community action. Engle et al. (2011), writing from the USA about transfer, illustrate that there is value in teachers establishing with their students that their learning has relevance to a 'wider community of interest' from the outset. Rheingold and Seaman (2017), also writing from the USA, describe the sense of pride and accomplishment students gained from working with 'experts' to produce field guides of local plants and animals that were made available for public use. They propose that for student project work to achieve optimal "motivational potential" (p. 13), students need to perceive what they do has utility for individuals and/or groups outside the school setting. Rheingold (2011) argues that when students—individually and collectively—are able to make a contribution to the "vitality of the community" (Miettinen, 2005, p. 63) through public performances and presentations, their sense of self and of their community is transformed and so are the relationships among students, teachers and the community. The potential for community involvement in STEM education has been highlighted directly by Burrows et al. (2018), Davis and Veenstra (2014), Diaz-Rubio (2013) and Kasza and Slater (2016), amongst others. Important to us, Penuel et al. (2016) note that STEM can play an important role in fostering student experience of learning in school, in the community and in family and online settings in ways that expand and enrich their student learning opportunities and resources. Community involvement can range from providing a motivating context to the exchange of ideas.

In New Zealand, the importance of community connection and contribution is emphasised in the community engagement principle in the *New Zealand Curriculum* (Ministry of Education, 2007). This states: "The curriculum has meaning for students, connects with their wider lives, and engages the support of their families, whanau, and communities" (p. 9). Building on this, it is also recommended that assessment encourages partnerships with families and communities through the reciprocal exchange of information (Ministry of Education, 2011). In Australia there seems less of an emphasis on community involvement, despite this curriculum being informed by t*he Melbourne Declaration on Educational Goals for Young Australians* (MCEETYA 2008), which held the key objective that all young Australians become "active and informed citizens" (p. 7). There are some examples of community involvement within the different learning areas of the Australian curriculum, but generally the principle of community engagement is surprisingly absent (Reynolds et al., 2020). As authors working in these two countries, we use examples from each place to illustrate (i) student engagement with community issues as a source of motivation; (ii) students accessing input from community members, and (iii) students contributing to the community (Mildenhall, 2021). Within each of these framings, community involvement can range from a single class partnering with different community groups or businesses, students engaging in informal activities with a small local organisation, or a structured programme that involves schools working with large organisations.

Student engagement with community issues as a source of motivation

Students can be engaged in, and supported to develop, their STEM understandings and skills through the exploration of local and wider community issues. This approach embeds student learning in a concrete issue which encourages an active learning approach. However, this relies heavily on teachers being able to identify issues that are, as we noted above, age appropriate and likely to be viewed by their students as related to their lives in some way. Student engagement and deep learning is more likely to occur when it is embedded in the students' cultural experience (Vygotsky, 1978). Dewey also asserted that "education must begin with a psychological insight into the child's capacities, interests, and habits" (1946, p.2).

Contemporary researchers concur that supporting students to make links between learning in school and issues within the real world enhances motivation and achievement (Albrecht & Karabenick, 2018). These issues can be identified through conversations, the media and the adaptation of commercial resources to teachers' context and students. One example of this latter approach comes from the STEM learning project in Western Australia (The STEM Education Consortium, 2018): *Bushfires*. Bushfires occur regularly in Australia with very serious impacts on people and their livelihoods as well as flora and fauna. Within the unit, students' science conceptual understanding such as humidity and temperature, mathematics skills including graphing and the technological skills to dow the product

design are developed as they learn about and then design an algorithm to consider the interaction of various environmental factors and meteorological data to provide information on the likelihood of a bushfire. Learners become involved with the community as they share their findings with community groups using digital media. Western Australia teachers who used the bushfire context found that the need to understand and reduce risk motivated students to understand the various aspects of STEM relevant to the problem. Hall (2021) details how this context was effectively translated into a New Zealand context by making links with the Nelson bushfires which had occurred earlier in the year that the students had worked on through the unit.

Students accessing input from community members

STEM professionals and community members can be invited into the STEM curriculum and classroom to contribute their knowledge, experience and practical support. The Australian government funded two projects of this kind. The *Scientists in Schools* (SiS) project, which ran from 2007 to mid 2012, was designed to introduce 'real-world science' into classrooms, to inspire and motivate teachers and students, and to increase scientists' engagement with the public (Rennie, 2012, 2015; Rennie & Howitt, 2009). More strategically, the intention was to establish scientist-school partnerships that endured beyond one-off visits, and it achieved this. Rennie notes that through the partnership process, scientists provided students with experiences that were usually additional to, and typically of, greater scientific depth than those their teachers could provide. Students came to appreciate that scientists were real people who could take the time to work with them, often on projects that took them outside the classroom. The project enhanced teachers' science knowledge and students' knowledge of the breadth of careers in science. The Scientists and Mathematicians in Schools programme (Campbell & Tytler, 2018) involved a partnership between schools and the Commonwealth Scientific and Industrial Research Organisation. This programme connects teachers with STEM professionals with the intention of supporting knowledge sharing over the long term. It aims to respond to local community needs and contribute to enhanced student reasoning in science and mathematics along with knowledge of how the STEM professionals work. Students reported increased interest, enjoyment, knowledge and confidence in science and mathematics as well as understanding of who might become a STEM professional. STEM professionals enjoyed sharing their knowledge of, and passion for, STEM while teachers reported increased motivation and engagement in teaching STEM.

Falloon and Trewern (2013) provide evidence of a positive impact of a partnership between the scientists from a government-owned science research institute and students from two Year 7 and 8 (ages 11–12) schools in New Zealand. Alongside benefits for teachers and students, Falloon and Trewern highlight the challenge of establishing partnerships, from the perspective of scientists where these include the nature of schools and teacher knowledge and workload as well as curriculum agendas and access to resources.

School-based visits by scientists can be challenging to arrange given the contingencies of school timetables and the constraints on scientists' time. Chen and Cowie (2016) make the case that videos of scientists talking about their work can be thought-provoking and compelling, thereby providing many of the benefits of face-to-face visits but with greater ease of access for scientists and teachers. The Science Learning Hub (https://www.sciencelearn.org.nz/) hosts videos by a large number of New Zealand scientists, meaning it is an important resource for teachers looking to provide their students with both information and an understanding of who can be a scientist in the New Zealand context. Cowie and Khoo (2015) provide evidence that master's students from a nearby university can fill the role of disciplinary expert, with the added advantage that they usually provide more closely age-related role models for school age students. In their study, students benefited from sharing and gaining feedback on their inquiry-thinking face to face and being able to continue the conversation via students' blogs and the class's digital noticeboard.

Of course, community groups and individuals can also be invited into the classroom to contribute to the curriculum. An example of this was two teachers inviting the local Men's Shed group to support their students to design a birdhouse for a raven with a damaged wing. As part of the design process the students learned about bird habitat and needs, they accessed ideas to inform their birdhouse design and they collaborated to use a range of mathematical and technological knowledge and skills in making a model of their birdhouse. Gauging how to ensure the entry accommodated the bird's damaged wing

provoked a lot of discussion about what shape and size hole the bird might be able to manoeuvre themselves through. The students presented and justified their design solutions to a local Men's Shed member. The Men's Shed member was so impressed with the designs he created a birdhouse from wood using a combination of the students' insights (Mildenhall & Sheriff, paper in development). In another example, Watters and Diezmann (2013) describe how members of the local businesses community supported junior secondary students to develop a worm farm business, in the process learning about life cycles, sustainability and packaging and raising community awards of recycling.

The teacher of a Year 7 class in New Zealand invited 'Auntie Gail' in to talk to her class about making ginger beer as a child, as part of a biotechnology unit on the modification of a traditional fizzy drink (Cowie & Moreland, 2015). The students learned and then used their science knowledge that 'yeast is alive' when modifying the traditional recipe to better meet the taste preference of their nominated consumer group, with modifications based on a consumer survey. They continued to develop and draw on technological knowledge and practices to test out their recipes and design marketing materials. In this example, Auntie Gail, as a member of the wider school community, provided insights into the cultural practices around making ginger beer and some of the perils if things went wrong (bottles exploding). Other members of the community were involved in the customer survey and taste testing.

In New Zealand, a class of Year 7 and 8 students studied kiwi—the distinctive features, typical habitat and the challenges they face with introduced predators. The class visited an organisation that had designed a predator proof fence where they learned about how possible solutions were trialled. They then visited Sanctuary Mountain Maungatautari (https://www.sanctuarymountain.co.nz/home), which is protected by the pest-proof fence. There they went on a guided walk where they searched for kiwi burrows. Back at school the students brainstormed criteria then designed and made a trap for rats and stoats. A local trapper visited the class and provided feedback on the trap designs. Across this series of tasks, the students developed science knowledge related to adaptation and conservation, and they experienced and learned practices and ideas to do with technology and engineering. This example illustrates that community input can be achieved by community members coming to school and children going out into the community. Input from passionate members of the community was important in fostering student interest and commitment to conservation and to their production of a creative but functional trap.

Students contributing to the community

Students can make a practical contribution to their community through their STEM inquiries. While the contribution they make depends on the issue, for the community and for the students it can be substantial. Students, because of their lack of preconceptions, can develop original and innovative ideas and solutions. Rennie (2006) provides an example of the impact of a Year 9 class's project to understand and raise community awareness of the reasons for poor air quality. The class erected air monitoring equipment and established a website that ensured up-to-date meteorological information was available to the community. Students who worked through the West Australian STEM learning project titled: *Honey bees* (The STEM Education Consortium, 2018) investigated the reasons for honeybee decline (Mildenhall et al., 2019). Undertaking an interdisciplinary STEM learning approach, the students enhanced their scientific knowledge through identifying the problem of honeybee population decline and understanding the contribution bees make to ecosystems. The students interviewed a local apiarist and designed board games with clues that required utilising their knowledge of the reasons for, and remedies to, honeybee decline. This activity required students to engage with the STEM design thinking process and work collaboratively and creatively. The students organised a community game day where community members played the board games they had designed. Participating community members reported that they had not only learned a lot from this experience but also that the students' passion had inspired them to consider taking actions such as planting more flowering trees and plants.

In an example from New Zealand, also focused on conservation and the role of predators (Chen & Cowie, 2013), Year 7 students studied the adaptations and conservation of New Zealand birds. The students investigated the presence of predators by using tracking tunnels they designed and located in their school gully. Then, of their own volition, some students constructed tunnels and placed them in their home gardens to track predator movement. Other students convinced their families to go for bush walks to look for native birds, to visit Tiritiri Matangi (a bird sanctuary), and persuaded their family to

ask for the fencing around a reserve to be repaired to keep predators out. In this example, students shared science and technology knowledge and their newly found commitment with their families, with many persuading their families to take action.

Concluding comments

In this paper we view STEM as an interdisciplinary subject that weaves together science, technology/engineering and mathematics in different ways and with different emphases depending on the context and topic of the teaching unit. We have illustrated how student motivation and engagement with STEM learning can be enhanced through a focus on local 'real world' events and issues. Community connection via community members contributing their expertise and/or students sharing what they have learnt can also support and enhance student learning and interest. Through their STEM inquiries, students can make a practical contribution to an issue of concern to the local community. From these examples we can see that community involvement can take different forms—from providing a context to a one-off informal connection with a person or community group and on to a sustained student-teacher-community partnership. Sustained partnership community connections are challenging to develop but they come with the potential to offer student access to a breadth of role models and to foster students' longer-term interest in STEM and STEM-related activities (Penuel et al., 2016). We hope that we have illustrated some of the ways teachers can enact these various kinds of community involvement in a way that encourages others to explore the potential of making connections with their community

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