STEM Outreach in Northern Queensland: The Importance of Providing Professional Development and Networking Opportunities to Educators

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Keywords: professional development, networking, rural-remote, STEM, secondary teachers

International Journal of Innovation in Science and Mathematics Education, *25*(5), 57–68, 2017.

Abstract

Teachers play a significant role as advocates for science, technology, engineering and mathematics (STEM) professions and through their work students are encouraged and enabled to progress to STEM related fields in higher education. In 2014, a multi-disciplinary team of tertiary educators provided professional development, capacity-building and networking experiences for STEM secondary educators in regional Northern Queensland. This Higher Education Participation and Partnership Program (HEPPP) funded outreach initiative focused on two key areas of the HEPPP strategic priorities of professional development; engagement and capacity building, to support the teachers in delivering science and science-related curriculum concepts. Hurdles arose between the professional development objectives and the situation of secondary schools in rural and remote regions experiencing social and economic challenges, seeking to leverage opportunities for enrichment and engagement with STEM initiatives and expertise. This paper is a retrospective account of the initiative's successes and challenges, paying particular attention to the complexities in STEM education in rural-remote locations and the importance of capacity building through networking opportunities.

Background

For over two decades, Science, Technology, Engineering and Mathematics (STEM) education in Australia has been described as being at 'crisis point' (Adams, Doig, & Rosier, 1991; Goodrum & Rennie, 2007) with calls in the literature to re-imagine science education (Tytler, 2007) in order to address the crisis. In 2012, the Office of the Chief Scientist authored two reports: Health of Australian Science (2012a), and Mathematics, Engineering and Science in the National Interest (2012b), highlighting the role of teachers, teaching and schools in addressing the crisis, as evidenced in the following extract:

> *Whatever we choose to do (and doing nothing is surely not an option), we should understand that success will result from a long-term investment—spanning generations. Therefore what we do must be at the heart of our education system, indeed a central plank in our educational philosophy: high quality, contemporary, engaging and equitable. … While universities need to examine how they offer science and mathematics to their students—especially in the early years—we need to ensure that the school sector maximises interest and provides opportunities for all students*

> *to study high quality mathematics and science leading to careers in those disciplines and in engineering. … Something different has to be done demanding a paradigm shift. There is a role for the Commonwealth working with states and territories to ensure that all Australians have access to an education that meets a high threshold of quality— while the content of the curriculum is delivered to suit local circumstances.* (Office of the Chief Scientist, 2012b, p. 6).

Rural and remote schools face challenges in the availability and the provision of professional development (PD) opportunities for educators due to geographic isolation, limited access to PD resources and low availability of support staff to relieve teaching time for PD involvement (Glover et al., 2016). Hansen (2009) and Rude and Brewer (2003) identified physical distance as being a major deterrent for ongoing PD provision in rural and remote schools. There are perceptions and assumptions that rural educators lack teaching resources and are working with out-of-date classrooms and laboratory equipment (Goodrum, Hackling, & Rennie, 2001; Lynch, 2000; Marlow & Cooper, 2008). Many secondary educators have multiple duties in a day in addition to extracurricular activities (Minner, Berns, Century, & Hiles, 2003) that can impede on PD opportunities due to time restraints. Some of the challenges associated with PD in rural areas are documented in research and note the need for consideration of the rural context (Howley & Howley, 2004; Oliver, 2007). However, there are limited reports on research into secondary educators' PD. Cicchinelli's (2011) review of rural educational research noted around 20% of studies focused on teacher preparedness. Since 2011, there have been studies focusing on preparing pre-service teachers (Azano & Stewart, 2015), professional development focusing on what educators have (Barrett, Cowen, Toma, & Troske 2015), instructional knowledge and classroom practice (Glover et al., 2016).

The aims of the 2014 initiative were to:

- Deliver specialised technical seminars, workshops, and demonstrations to secondary educators to assist with the creation of engaging real world science curricula (professional development).
- Initiate local collaborations and co-teaching strategies with target schools through networking opportunities (capacity building).

The following is a retrospective account of the initiative's successes and challenges in professional development (just-in-time information, tools and skills to build confidence) and capacity building (resource assumptions, geographic location, scheduling and cultural sensitivity). These ultimately led to the creation of a self-evaluation auditing tool (Table 2). The auditing tool in Table 2 frames enrichment activities in terms of cultural sensitivity, sustainability, relevance and resourcing with a view to circumventing issues and challenges for others embarking on similar enrichment work.

The 2014 initiative

Since 2013, Higher Education Participation and Partnership Program (HEPPP) funding has been allocated from the Australian Federal Government to universities by a formula based on the number of students from low socio-economic status (SES) backgrounds enrolled at each university. Within the universities, funding was allocated through competitive grant rounds. In 2014, three strategic priorities of the HEPPP – Partnership Component were:

- STEM, including participation in science related subjects, and a targeted push for increased Indigenous participation and encouragement into science related areas.

- Professional development for primary and secondary school teachers, and school staff.
- Engagement and capacity building with educational partners and other key influencers (as critical to positively influencing the choices of young people towards higher education pathways).

The 2014 initiative focussed on two key areas within the HEPPP strategic priorities: (1) professional development and (2) engagement and capacity building opportunities for secondary school teachers in a Northern Queensland, Australia setting. The four schools included in the study were identified as priority schools according to HEPPP guidelines, which categorise schools one to four, with category one regarded as having the highest need (Department of Education and Training 2014).

The four HEPPP priority schools included two schools reported as priority 1 and two schools priority 2. The two priority 1 schools were Indigenous (Aboriginal and Torres Strait Islander) boarding schools and the priority 2 schools had a <25% Indigenous student enrolment. The four schools were located within a 300-kilometre radius of the James Cook University (JCU) Townsville campus, considered as Northern Queensland.

The JCU student demographics in 2014 were: 22,784 students with 57.4% (13,077) in Townsville, 7,574 (33.24%) International students, 4.50% Australian Aboriginal and Torres Strait Islander, 22.80% Low SES, 21.90% Regional/Remote, 60.1% Female, 33.9% Male. A multi-disciplinary initiative team of tertiary educators from JCU and the four secondary schools team of educators worked together in a collaborative approach (discussed later) to appraise the need for professional development and capacity building experiences for STEM secondary educators in rural and remote Queensland.

Rural and remote

There are numerous definitions for ‘rural’ and ‘remote’ however most tend to be in association to an urban-centric deficit view of geographical remoteness with connotations of low socio-economic status (McConaghy, 2000). Hardre, Sullivan and Crowson (2009) suggest some rural individuals tend to aspire to vocational rather than academic streams of education and training with an emphasis on practical components. When vocational education is not readily available the academic stream is sought out with most rural and remote individuals needing to relocate. Many students experience cultural dissonance, place detachment and stress, in adjusting to new and unfamiliar surroundings (Dees, 2006).

Cultural sensitivity (Indigenous specific considerations)

The sense of place can be associated with memories, activities and relationships that contribute to personal identity and self-efficacy with a particular physical setting (Low & Lawrence-Zumiga, 2003). This sense of place is particularly relevant for Indigenous peoples (Aboriginal and Torres Strait Islander) and can lead to challenges of adjustment while staying at boarding school or while engaging students with curricula. For Indigenous peoples the world is alive with ‘being’ compared to the western concept of the world having in animate objects (Lehman, 2008). It is the ‘being’ that gives places spiritual and cultural significance. It is these socio-cultural beliefs and practices that emphasize identity and belonging within a past, present and future time continuum which can underpin displacement experiences during short and long term separation (Rumsey & Weiner, 2001).

The time continuum and the world being filled with 'being' can be challenging for traditional teaching practices particularly in maths and science. In the past, there has been a lack of recognition for spatial and cultural diversity in education and the homogenization of globalization which has been addressed in recent years (Teese & Polesel, 2003). The concepts of time and place and the requirement of being at a certain place at a certain time can lead to student duality and misinterpretations, not to mention frustration. Time and space are compartmentalized within mathematical concepts in western thinking compared to a continuum of time, space, events and locations that can be fluid categories of thought (Tuhiwai-Smith, 1999).

Indigenous spirituality and an animistic world where people, plants, animals, landforms and celestial bodies are interconnected and form part of a larger reality must be taken into account in the design of teaching activities. In an animistic world nothing is inanimate, everything is alive with natural forces that are energized by a spirit and humans are on an equal footing with nature with a moral obligation to treat everything with respect (Grant, 2004; Grieves, 2009). The spiritual and animistic world concepts, in addition to totemic spirituality where natural objects, plants or animals are inherited spiritual emblems by members of a clan or family, can be a challenge in a science curriculum or on scientific field trips as these totems are believed to be the descendants of Dreamtime heroes or totemic beings (Grant, 2004). Such cultural beliefs pose significant challenges for typical approaches to anatomy teaching for example. Cultural sensitivities (Baxter & Meyers, 2016) are important considerations during the design of projects and activities aimed at engaging STEM students from diverse cultural backgrounds in life science activities.

Professional development

The creation of professional development opportunities between stakeholders within the university and the four secondary schools was a challenge due to a variety of issues which differed between schools. These differences included: educators being time-poor, a lack of resources, variations between timetabling of secondary and tertiary schools, tertiary teaching activities and cultural diversity to name a few. Secondary schools set their curriculum 12 months in advance, limiting changes and innovations that can be incorporated in a 12 month initiative. The limited scope for transformative practice suggests the need for the timeline of initiatives such as HEPP to be revised so as to allow for substantive shifts in practice to be trialed between partners from different educational sectors (university, secondary and primary).

At the onset of the initiative there were assumptions made by the tertiary educators about the availability of resources and equipment at the secondary schools. During the initiative conception and development, the tertiary educators had assumed that content and access to university resources would be desirable. It became apparent however, that secondary schools had existing resources, and were interested in working with tertiary partners to develop innovative ways to demonstrate and teach real world scientific concepts using the resources they already owned. Working together involved cooperation and partnership at the level of program implementation and networking in terms of engaging the educators through professional development workshops, rather than just targeting staff at individual schools.

Based on the needs of the educators, a sample of the just-in-time professional development bites were developed and showcased in the form of integrated instructional knowledge workshops (Glover et al., 2016). Innovative approaches to the use of data loggers, molecular scientific equipment and electronic voting tool training instruments were personally delivered and made available as future on-line resources. The provision of just-in-time information, tools

and skills allowed the individuals to reap the benefits of applying their newly acquired skills (Godlee, 1995). An individual's need for just-in-time information/support transforms the individual from a passive recipient to an active participant that will transmute the information as required for their unique application. The importance of providing just-in-time information to first and second year university students to thrive (Taylor, 2017) in addition to personal and social support (Taylor & Harrison, 2016) seems equally important for tertiary and secondary educators to thrive.

The professional development workshops aimed to build confidence and awareness of innovative equipment/technology usage and teaching practices in a networking environment. The following are some examples of contextually relevant, meaningful, practical and vocationally relevant activities conducted as part of the 2014 initiative.

The JCU initiative team worked in collaboration with the 2014 State Manager of the North Queensland CSIRO Education team to promote the CSIRO secondary and primary schools mobile education programs and JCU provided complementary parasitology (Blood & Bugs) and physiology (Breathe & Beat) university activities for the participating schools. Three of the four schools engaged with the Cool Chemistry, Forensics – Cattle Duffing Scenario, DNA and Telescope viewing with Starlab CSIRO programs. It is worth noting that all of these activities were individually modified to suit the students' needs and the current curriculum requirements of each school. The CSIRO and university activities had practical, hands on vocation type approaches which appealed to the rural and remote students (Glover et al., 2016).

The ability to deliver inspired science and technology related activities assists in providing students with broader knowledge of career opportunities in STEM. The students received opportunities to interact with university educators within the university environment which also provided networking opportunities for the secondary students and the educators, in addition to demystifying the university setting for the students. It is well established in the literature that there is no limit to the tertiary success of students from diverse backgrounds (eg: rural and remote origin, low SES, first in family, Indigenous heritage) if a structured and engaging transition from secondary school is provided (Taylor, 2017; Taylor & Harrison, 2016; Tinto, 2012).

Some of the secondary schools in this initiative took advantage of opportunities to strengthen their students' awareness of university structures and, pathways by engaging in the university type science classes and laboratories. Student engagement involved the development of learning and teaching activities that both enhanced the school's academic curriculum and provided the students with the opportunity to explore the possibility of being a part of the university and urban community in the future. Given the demographics of the priority schools, the delivery of these activities posed challenges that the tertiary education team had not envisaged such as: cultural sensitivity and geographic challenges for boarding school students; the sense of place and displacement felt by some students; and the challenge of scheduling on and off-campus activities.

Capacity building

Based on the literature, the term capacity building has been diversely conceptualized and a multitude of meanings attributed to it (Selsky, 1991; Preskill & Boyle, 2008). The components of capacity building definitions tend to include a conception of collective development that taps into existing abilities of individuals, communities and/or organizations to address perceived inherent obstacles. Crisp, Swerissen and Duckett (2000) suggests there are four

approaches to capacity building which include an organizational top-down (changing agency policies or practices) or bottom-up (provision of skills to staff) approach, a partnership (strengthening relationships between organizations) approach and a community organizing (individual community members form new or join other organizations) approach. For the purposes of this initiative, capacity building focused on a partnership approach to increase self-sustaining abilities of individuals to recognize, analyse and effectively solve challenges while utilizing existing and new resources (de Graaf, 1986; Murrary & Dunn 1995; Robertson & Minkler, 1994).

Most successful capacity building initiatives are those which are initiated and run by members within similar communities, or those that share similar interests and challenges and where there are perceived benefits to all parties. The 2014 initiative was delivered by JCU multi-disciplinary tertiary educators that shared a common interest with the secondary school educators in science education, student engagement and STEM (Masters, 2006; Osborne, 2006). The unique approaches to capacity building in this initiative lead to the development of ongoing relationships between the providers and the recipients. The initiative built upon the existing strengths, abilities and resources within the secondary educators and the schools' environments by providing professional development and networking opportunities (capacity building) for the secondary STEM educators.

The importance of teacher engagement is heavily documented and highlights teachers as advocates who are significant in empowering student progression to higher education. Establishing a partnership between university and targeted secondary schools through the delivery of professional development seminars, workshops and co-development and delivery of practical laboratory classes and curricula to improve student awareness of science was key. Developing students' understanding, experiences and engagement in STEM at a secondary school level and removing the unknown in university expectations will serve to bridge the gap between secondary and tertiary education and reduce the students' first year experience transition (stress and anxiety), that is commonly experienced (Taylor & Harrison, 2016; Taylor, 2016).

Collaboration partnerships and networking

The initiative developed lasting partnerships with educators from the four target schools through an integration of professional development activities, co-curriculum development and delivery, networking and the sharing of ideas between secondary and tertiary educators. The development of collaborative partnerships between individuals and organizations that might otherwise have minimal interaction (Chavis, 1995) is the principle of networking and the two-way flow of information, experiences and expertise can lead to innovative approaches to overcome education challenges. During this initiative, the JCU team partnered and collaborated with a number of additional learning institutions and learning support initiatives and individuals; see Table 1 for a list of some of the partners and participants in this initiative. Sharma et al. (2017) found the collaborative approach improved science and mathematics teaching by enabling the embedding of effective innovations.

The word 'networking' is typically used in reference to building a personal network to further one's career (Addams, Woodbury & Addams, 2010) or working a room to build contacts (Nierenberg. 2006). For the purpose of this initiative we looked at networking as a pyramid strategy where individuals could gain insights from another's experience, expertise or skills set (Uzzi & Dunlap, 2005) in a friendly, mutually beneficial, relationship with the emphasis on potential partnerships based on mutual benefits (Hochberg, Ljundqvist, & Lu 2007).

This initiative provided the tertiary educators with an opportunity to establish collaborative partnerships with four secondary HEPPP priority school educators, James Cook University scholars, the Museum of Tropical Queensland staff and the CSIRO Education North Queensland secondary school program staff.

Partnerships and a sense of community developed naturally between the educators, scholars and the industry education support individuals based on mutual aspirations, goals and challenges. For example, educators with similar professional qualifications and interests from two of the secondary schools with similar student demographics, shared knowledge and resources to redesign curricula, creating a unique learning opportunity for their students. They also organized joint events in which the student cohorts visited the museum and assembled at one of the schools where the students were able to socialise with each other to share knowledge and to reflect on their learning and social environment; an example of a sharing and co-mentoring environment for both the students and the educators alike. Table 1 summarises the individual teams associated with the initiative across a variety of activities and engagement approaches.

Table 1: Collaborative partners and participants that participated on this initiative

Partners in the Initiative	Partner Relationship
Museum of Tropical Queensland	Collaboration with the Museum director and the education staff to promote the education support services available at the museum and to work with the secondary educators to provide complementary program activities. Informal agreement for mutual benefits
CSIRO Education	Collaboration with the State Manager of the North Queensland CSIRO Education team for cross promotion of the CSIRO mobile education programs and to pool resources. Working together in the program delivery by providing complementary program activities. Informal agreement for mutual benefits
James Cook University Teaching, Learning and Development Team	Continued collaboration and partnering with the Teaching Learning and Development team at JCU to continue to support secondary school educators and their students. Informal agreement
James Cook University Marketing Team	Continued collaboration and partnering with the Marketing team at JCU to continue to cross promote the James Cook University Open days, UNI Experience days and all other activities that will engage secondary students to reassess their view of science, their engagement in science and their perceived capabilities. Informal agreement
James Cook University Tertiary Scientific Educators	Continued collaboration and partnering with the Biomedical Science educators at JCU to continue to cross promote the life sciences at James Cook University and to engage secondary students to reassess their view of science, their engagement in science and their perceived capabilities. Informal agreement
The Secondary Schools	Continued collaboration with the principals and their teaching teams to continue to provide professional development tools and

opportunities in addition to developing and providing university science tasters that can be parachuted into the secondary teaching curriculum as required. Informal agreement for secondary school educators and student benefits and support.

Challenges to be considered

In this initiative there was a need to negotiate well in advance to take budgetary constraints of schools into account since budgets and curriculum are set early in the calendar year to meet logistical needs for schools to participate in off-campus activities. Other unanticipated requirements for off-campus activities included student permission slips which needed to be planned months in advance to enable remote students in boarding schools to return home for parental permission signatures and to obtain appropriate footwear for scientific excursions and/or scientific laboratory work.

Secondary educators plan on and off-campus enrichment activities to spark student interest in sciences and maths as a means of encouraging them to continue with these subjects beyond grade nine. While there has been some progress in the Commonwealth Government 1990's equity objectives for disadvantaged groups' participation in higher education, levels of academic readiness for Indigenous students completing their secondary education remains low (Anderson & Potok, 2010). For secondary schools to participate in enrichment activities, awareness is paramount in creating meaningful, contextually relevant, and culturally sensitive enrichment activities relevant to all educators and their students.

Self-evaluation auditing tool

Sustainability of outcomes is a challenge in one-off funded initiatives due to the paradoxical nature of capacity building and networking that are intended to produce long-term changes (Addams, Woodbury & Addams, 2010). Funding bodies and funding applicants that adopt a capacity building approach need to be clear on the initiative strategies and outcomes and what is feasible within a relatively short timeframe (less than a year). A potential approach could be to focus sustainable long-term improvements in capacity building from short-term efforts. The following auditing tool in Table 2 provides a frame for capacity building and enrichment activities in terms of cultural sensitivity, sustainability, relevance and resourcing with a view to circumventing issues and challenges for others embarking on similar enrichment activities.

Table 2: Self-evaluation auditing tool for the sustainability of enrichment activities.

Areas of significance to frame an enrichment activity	Prompting questions to frame the initiative conception
Initiative aims	• Will the timeline allow for significant shifts in practice between cross-sectoral partners? • Is the initiative premised upon assumptions about the needs of cross-sectoral partners? • Will the funding be made available to school sector partners to cover costs of transporting students for engagement activities? • Has timelines been conceded from all collaborators' and partners' perspectives? • What is the history with the school sector partners with similar initiatives being proposed?

	• How might past history with one-off initiatives influence potential partnerships?
Imperatives of the funding sources	• How do the strategic imperatives of the funding body influence or shape the outcomes of the initiative? • Do the strategic imperatives distort the intent of the initiative? • What methods have been used to ensure that the identified goals are consistent with the goals of the initiative partners? • Are the partners' conceptualization of the initiative output expectations appropriate and compatible with the repertoire and strategies of the initiative leaders?
Relevance for partners	• How does the initiative enhance the existing planned curriculum for the school partners? • How does the initiative extend the professional expertise of the secondary school teachers at the partner school? • How does the initiative extend networking opportunities to other potential partners? • What are the common concerns raised by the initiative partner groups that are culturally diverse?
Cultural considerations	• Has the initiative taken into account the demographics of the partner schools and is a cultural liaison advisor part of the initiative team? • What are the cultural influences on how the initiative leaders view the desirable initiative outcomes? • Are the concepts of the initiative in line with cultural considerations and requirements? • What will be the cultural context of the initiative in relation to the cultural context of the initiative leaders?
Innovations for sustainability	• Who will remain as the contact for the initiative beyond the funding? • How can the initiative be extended or elaborated upon in order to maximise opportunities for future funding for the cross-sectoral partners?
Intended outcomes	• How will each of the cross-sectoral partners benefit from this initiative? • Do the benefits outweigh any potential costs? • How are the choices of initiative interventions influenced by the initiative leaders' preferences for working with others in a particular way? In what ways might these interventions need to be modified to work effectively with the initiative partner groups? • What attitudes, knowledge and skills might the initiative leaders need to develop to work more effectively with the initiative partners?
Methods of evaluation	• Which methods will be used to seek feedback from teachers at partner schools in relation to the outcomes of the initiative? • Will these methods negatively impact on teachers and their existing workload? • How will this feedback be acted upon once collected? By whom? • How will this feedback be shared with teachers at the school, and used to leverage additional resources or collaborations for the school community?

- If feedback on the outcomes for the initiative is to be sought from students, have ethical implications been considered, including timeframes for ethics applications and approvals?
- What are the important indictors in the initiative partners' cultural context that demonstrates how the initiative outcomes have made a difference for them and/or their students?
- What indicators of success have been established with the initiative partners to determine that the work together has been successful and when it will be completed?

Conclusion

In initiatives such as this, it is important to consider the sustainability; what can be done to provide ongoing engagement and support? A virtual presence such as online resourcing for follow-up or re-visiting professional development information can be invaluable. The creation of curriculum packages that schools can adapt and parachute into existing curriculum programs in ways that are contextually significant are also beneficial to secondary educators.

The sustainable outcomes from this initiative were twofold. Firstly, the resources generated from this initiative enabled the development of a resource for continued provision of secondary educator support to address the STEM crisis. Secondly, and perhaps the most valuable outcome of the 2014 study, has been the establishment of partnerships with secondary schools within the region and our key initiative partners which will drive future collaborations to support the secondary educators and their students.

Grant funding was used to formalise and strengthen engagement with priority schools to put in place sustainable structures for delivery, based on good practice, consultation, research and responsiveness to school needs. As such, this initiative resulted in the establishment of robust frameworks that underpin successful delivery, in particular, formal school partnership frameworks. Under these networking and collaborative frameworks, and with additional networking partners, the delivery to the schools and school communities has been enhanced and deepened for the secondary and tertiary educators and the collaborative partners.

Acknowledgments

The authors would like to thank the 2014, Higher Education Participation and Partnership Program (HEPPP) Grant for funding this initiative. The authors would also like to thank all of the networking partners and participants that helped to make the initiative a success. Thank you to Dr Harrison and Dr Doyle for their contributions. Special thanks to the schools for their journey with us.

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