Chapter 8
Stimulating Australian STEM Education in Regional Queensland Through a Novel School–University–Industry Partnership

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Introduction

The Science, Technology, Engineering, and Mathematics (STEM) crisis involves a shortage of students—the next generation, who will be responsible for our futures—studying STEM. The future without people having competency in STEM disciplines will be problematic as over 75% of jobs now require STEM skills (Chubb et al., 2012). STEM is vital to all aspects of the nation's growth including Australia's competitiveness, health and well-being, and prosperity (Office of the Chief Scientist, 2014). One method to address the STEM crisis is to look at the way STEM is taught in schools and to develop educators' skills in teaching STEM-based curriculum to be more engaging and innovative to spark interest in students for future employment within STEM (Department of Education, 2016). As a result, STEM in the Gladstone region has a 'space, place, and face' and importantly is being replicated across the Central Queensland University (CQUniversity) regional footprint. The Queensland Government invested $2.8 million in the Advanced Technology and Innovation Centre (ATIC) to support industry and education in Central Queensland, which was modelled on the design of STEM Central in Gladstone (Queensland Government, 2020).

The school–university partnerships in Gladstone through STEM Central have evolved, and the strength of the partnerships is the fluidity to respond to local needs and opportunities. Within this chapter, the key strength in the combination of industry, university, and primary and secondary school sectors is explored. Findings showed that each key partner brings different perspectives to the project in

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addition to addressing a common long-term vision of improving STEM education to tackle STEM skill shortages in the local region. As a result of this innovative and research-driven space where school communities could have access to professional and contemporary thinking based on research and evidence from a wide variety of STEM education professionals, local schools displayed a willingness to try new ways. In turn, schools then took the opportunities that were provided to deliver STEM education for students in the region. This chapter aims to provide insights into these deliveries and reflect on the future design and sustainability issues within the novel university–school–industry partnership of STEM Central.

Background Literature

This literature section explores key themes within the research that underpins the STEM Central school–university–industry partnership. Pertinent to the development of the discussion pertaining to this partnership are the emergent tensions and challenges inherent in the STEM education space, particularly in the proficiency of teachers when delivering STEM content in the classroom. These aspects are also influenced by the policy implications of embedding effective STEM teaching and learning approaches in both school and university contexts.

STEM Challenges in Australian Contexts

Over twenty years of reports and articles from government, business, think tanks, and the media have drawn attention to the Science, Technology, Engineering, and Mathematics (STEM) learning problem (Timms et al., 2018). Challenges in STEM learning in Australian Schools (Timms et al., 2018) and the Advance Queensland Strategy have identified eleven priority industries that support growth in the region (Queensland Government, 2019). Investment into STEM education and research has been recognised as critical to the future success and growth of the country. In 2016, the Education Council released the National STEM School Education Strategy (the Strategy) 2016–2026. The two goals of the Strategy were to.

- Ensure all students finish school with strong foundation knowledge in STEM and related skills and;
- Ensure that students are inspired to take on more challenging STEM subjects.

With these significant statistics and goals in mind, CQUniversity identified the need to assist regional teachers to engage with STEM and learn new ways of teaching STEM.

Providing real-life and contextual applications is fundamental when providing STEM experiences, and this method requires teachers to draw upon their knowledge, skills, and creativity (Nadelson et al., 2013). Limited confidence in approaching this style of teaching and learning is often seen in teachers when teaching STEM

curriculum either informally or in the classroom context. In their research, Lee et al. (2004) acknowledge that a limited number of teachers were sufficiently prepared in their knowledge of science content or teaching strategies and required professional development opportunities to increase their knowledge and instructional skills. These factors demonstrate the need for teachers to be provided with the opportunity to experience and engage in practical STEM teaching and learning opportunities with the ability to seek feedback and reflect prior to embedding this in their teaching (Nadelson et al., 2013).

STEM Central aims to develop a model of institutional interdisciplinary collaboration for developing curriculum and resources. Working with teachers' strengths and including an approach that respects the intellect, curiosity, and questioning of educators provides the opportunity to connect with science comfortably (Howes, 2002). Curriculum design needs to be innovative, and a range of science curricula and resources need to be developed. STEM curriculum should be flexible, adaptive, and integrated rather than as an add-on program. When working with teachers, providing a range of possible science ideas and activities that could be used in the classroom introduces participants to research processes, establishes connections, and acknowledges their talents.

School–University–Industry Partnerships

Findings from a recent report into *The Review of STEM Education in Queensland State School*s Final report 2018 included that STEM education can be strengthened with increased access to sustained and specialised professional development, students exposed to positive STEM experiences and access to STEM resources within the community (Queensland Government, 2018). Amongst the six key strategies within this report was the inclusion of promoting and establishing partnerships between schools, universities, community, and industry. Outlined as the reasoning behind these partnerships was the emphasis on real-world examples for students learning in addition to increasing the capability of teachers to feel "confident about their STEM knowledge and use of effective STEM pedagogical practices" (Queensland Government, 2018, p. 13).

The National STEM School Strategy: a comprehensive plan for Science, Technology, Engineering, and Mathematics education in Australia (Education Council, 2015) identified five key areas for national action through which school education has the greatest leverage. These include.

1. Increasing student STEM ability, engagement, participation, and aspiration.
2. Increasing teacher capacity and STEM teaching quality.
3. Supporting STEM education opportunities within school systems.
4. Facilitating effective partnerships with tertiary education providers, business, and industry.
5. Building a strong evidence base.

Research has shown that the more fully a collaborative partnership considers the various types of expertise possessed by its members, the more richness of understanding and direction it will receive (Zetlin & MacLeod, 1995, p. 6). Successful collaborations are dependent on supportive and strategic leadership at multiple levels, including top-level institutional leaders, partnership-level leaders, and day-to-day leaders (Miller & Hafner, 2008). Community partnerships have been discussed as powerful in their connections with schools as according to Tytler et al (2018), although teachers are trained in certain areas, they cannot bring the same "depth of understanding" of practicing or trained STEM professionals (Tytler et al., 2018). Developing links within the community that includes university and industry-based STEM facilitators enhances the opportunity for engagement both of students and teachers in the STEM education space (Zeichner, et al., 2015).

Methodology

This chapter applies case study methodology to first outline the context of the school–university–industry partnership and then describes two significant projects as cases that were designed, developed, and implemented through STEM Central. A case study approach was applied as this chapter explores a specific context and provides a way of investigating university–school–industry connections within this context (Atkins & Wallace, 2012). Each case was developed to include the genesis of the programme and related funding, the teaching, and learning foci, the participants in the programme and discusses the general outcomes of each program.

What Is STEM Central?

STEM Central is a purpose-built space for collaboration and research-based learning located at CQUniversity Gladstone Marina campus. The state-of-the-art facility consists of seven interchangeable brightly coloured zones including a zone for flying drones and a dark room for light and VR experiments with a green screen wall for filming. The design of the facility included not only the development of a physical space but also associated educational programmes aimed at upskilling teachers, inspiring school students and engaging the community in a future fuelled by STEM knowledge. The resources include a variety of robots for coding, drones, 3D printing, building catapults, holograms, and much more. The facility has fostered and enabled the growth of STEM capacity, giving local people the confidence and interest to acquire the STEM skills they need to nurture their community and achieve global competitiveness. Programmes at STEM Central include workshops for the early years, Indigenous people, people with a disability, seniors, multicultural, all of the community. Partnerships have developed with national and international organisations including Questacon, the Commonwealth Scientific and Industrial Research

Organisation (CSIRO), Queensland Museum, Office of the Queensland Chief Scientist, Rio Tinto, Shell QGC, Santos, Inspiring Australia, schools, education providers, Universities including QUT and MIT, and STEM Central funding partner ConocoPhillips, Australia Pacific LNG. The facility has brought together university academics, teachers, school children, industry, and the wider community to enhance the local community's understanding of STEM and provided a 'place, space, and face'.

STEM Central has a strong educational focus and provides local teachers with the necessary support to effectively engage students with learning opportunities in a hands-on problem-based learning approach. STEM-related content is taught and applied either in a traditional and discipline-specific manner or through a multidisciplinary, interconnected, and integrative approach. Both approaches are outcome-focused and aim to solve real-world challenges. The schools in the regional area of Gladstone form a critical part of a broader STEM education ecosystem which includes pre-schooling, vocational education and training, higher education and workplace training and development. In addition to supporting teachers, the programmes and associated research opportunities within STEM Central also provide the necessary support to effectively engage students with STEM opportunities in an inquiry learning approach which is critical to addressing the STEM crisis. The project team recognised that to create learning environments conducive to STEM skill development for children there needs to be the appropriate skill development and understanding of the scientific process for educators. STEM Central aims to provide valuable, enriching experiences to bring STEM to life, and these experiences were often opportunities that most local teachers did not generally receive. This is due to the lack of local STEM professional development opportunities in the Gladstone region as many professional development offerings were either online or in capital cities. STEM Central is not only a facility used with schools, but also with community, businesses, and industry. It provides a 'place, space, and face' as a central hub for the community. The development of this space is seen as being critical to addressing the STEM crisis through effective partnerships with business and industry.

A Collaborative University–School–Industry Partnership that Responds to the Needs of the Region

Gladstone region is home to more than 60,000 people and accommodates 21 private and public primary and secondary schools. The regional city of Gladstone is in Central Queensland, situated approximately 510 kms (320 miles) north of Brisbane, the nearest capital city. The region is diverse, containing both seaside and rural communities. Gladstone has the State's largest multi-commodity shipping port, the Port of Gladstone. Gladstone is home to a range of industries, including the world's largest alumina refineries, an alumina smelter, a power station, cement and chemical manufacturers, and three Liquefied Natural Gas (LNG) plants on nearby Curtis

Island. Gladstone is set to become one of the world's largest hydrogen equipment manufacturing hubs with multiple hydrogen industry initiatives recently announced (Queensland Government, 2021). As this background would suggest the Gladstone Region has a strong industrial base, well developed infrastructure, and many of the employment opportunities are based around STEM careers (Pfeiffer & Tabone cited in Fitzgerald et al., 2020).

The Port of Gladstone is considered the gateway to the Southern Great Barrier Reef, which brings a strong focus on the environmental sciences to the region. Gladstone has historically been a town of industrial development in peaks and troughs. It is argued that Gladstone has experienced these industrial development cycles over many years and has managed to weather them relatively well (Cameron et al., 2014). Against this backdrop of industry, there coexists many important coastal habitats, such as mangroves, saltmarsh, sand and mud banks, coastal reef, sand dunes, and seagrass. This unique combination of large resource industries and the World Heritage-listed Great Barrier Reef provides a niche context for local and contextual science learning experiences to be developed.

CQUniversity has strong connections with schools through the outreach and engagement programmes and activities that have been developed and implemented over a number of years. Activities such as trips to Quoin Island Turtle Rehabilitation Centre in partnership with local schools as well as annual science week events have enabled a strong relationship between the university and education providers to thrive. These programmes and activities have also involved industry and community partners who have provided support either through direct funding or by providing subject matter expertise. This broad approach appealed to Australia Pacific LNG as there was a recognized skills shortage for STEM professionals. Instead of funding individuals or smaller programmes, Australia Pacific LNG supported the partnership approach that CQUniversity was growing with schools and community to grow the STEM career pipeline.

Initially, STEM Central was created within a university–industry partnership between Australia Pacific LNG and CQUniversity to design, develop and implement the STEM Central facility and associated programmes which arose out of the need to improve education outcomes by providing professional development for teachers rather than from an engineering or environmental science focus. The model was a deliberate effort to foster partnerships with schools through a professional development focussed on making STEM interesting and appealing for students, thereby increasing the number of STEM professionals in the system. Over time, in response to the needs of the region, STEM Central has evolved from professional development for teachers into a 'place, space, and face' not only full of resources and programmes but where partnerships between the university, schools, and industry can flourish within the community.

STEM Central University–School–Industry Partnership Case Studies

Since STEM Central opened in 2018, there have been hundreds of events, programmes, workshops, and activities held at the facility. Strategic funding opportunities have ensured that there is no charge to use the facility, and the project team have actively promoted the use of the facility to local community groups, services, and organisations. There have been a wide range of diverse community members utilising the facility. The project team has targeted various groups who have not traditionally been involved in STEM and offered programmes and activities to engage them with STEM. The following cases outline two recent programmes that have been developed and delivered through the school–university–industry partnership of STEM Central.

STEM Professional Development (PD) for Year 3 and 4 Teachers

Current educational research around STEM teaching has brought tensions to the surface around the capacity, capability, and willingness of teachers to instruct unfamiliar subject matter. These current considerations highlight the need for formal training for classroom teachers in the STEM space. It is vital to develop innovative programmes to provide practicing teachers with quality STEM professional development. To develop quality professional development (PD) that embeds authentic opportunities, there is a need for industry involvement. The PD in this case study was targeted and authentic in design as it brought together knowledge and facilitation expertise from both industry-based and university-based STEM providers, researchers, and teachers. The STEM PD was funded by Australia Pacific LNG as part of the STEM Central project funding. The challenges associated with this programme was that although the programme included funding for teacher release, with a chronic teacher shortage in Australia and even greater in regional locations, some schools who expressed interest in sending their teachers simply could not find replacement casual relief teachers. The PD involved 12 participant teachers, one group of six Year 3 teachers and another group of six Year 4 teachers. The goals of the PD were to provide the participant teachers with opportunities to create student-centred approaches and for their students to become problem solvers and critical thinkers using science skills and understanding, and the engineering design process (EDP). Each group of teachers attended in pairs from the same school based in regional contexts. This was intentional to encourage peer support and provide an opportunity to apply STEM project-based learning principles in the following school term. The 12 teachers involved in the study were from four schools both government and non-government.

Teacher participants from both the Year 3 and Year 4 contexts discussed the challenges of embedding STEM strategies linking to curriculum constraints and "control

from above" (Teacher—Year 4). One Year 4 teacher discussed the notion of control as "you must do that test and that test" constraining the opportunity to include learning from their STEM PD in their classroom. In response to an interview question relating to the future of embedding STEM in their classrooms, both teacher participants from Year 4 made specific reference to the concept of a 'barrier' of embedding the learnings from the STEM professional development and curriculum requirements. The direct reference to the C2C (curriculum to classroom) assessment task is specific to the Queensland context: "because we are working toward a C2C assessment task, that threw up so many barriers and I remember we sat there and ran through so many ideas and came to a dead end at different points" (Teacher—Year 4). The Year 3 teachers also included in their response to the future of integrating STEM strategies in their classroom as being "unlikely" due to their teaching instructed being impacted "heavily by C2C" (Teacher—Year 3). Successes of this programme included the small group and individualised PD provided for the teachers, the opportunity to experience student-centred inquiry first-hand and the time available to develop projects that were able to be implemented in the classroom. The university–school–industry partnership provided a local context and STEM Central provided a 'place, space, and face'.

Year 9 and 10 Science Experience

The 'Science Experience' (formerly The ConocoPhillips Science Experience) is a three-day experience developed by university Academics to immerse Year 9 and Year 10 students in authentic science related to research. There are programmes across Australia at many different universities. Each programme is designed to provide students with an opportunity to participate in a wide range of engaging STEM activities under the guidance of experts in the field who are passionate about their work. The programme takes place in over thirty-five universities and tertiary institutions, within many different laboratories and lecture theatres. Participants conduct experiments in the university laboratories, meet and hear senior lecturers in the lecture theatres, attend site visits and walk around and experience what it is like to be on the campus of a university or tertiary institution. More than 81,000 students have taken this rare opportunity across Australia, up to date. The programme also provides information about further studies in STEM. It highlights the wide range of careers that allow students to pursue their interest and abilities in the sciences.

In Gladstone, the 'Science Experience' has been offered since 2015 at CQUniversity Gladstone Marina Campus. The programme has been developed using the technology, industry, and environmental science focus afforded by the location. Over time, the framework for the programme has evolved and is based on the model presented in Fig. 8.1.

This model includes bringing together presenters and sessions that are hands-on for the students. Allowing the students to experience sessions on the university campus allows them to experience "a day in the life of…". Along with the authentic

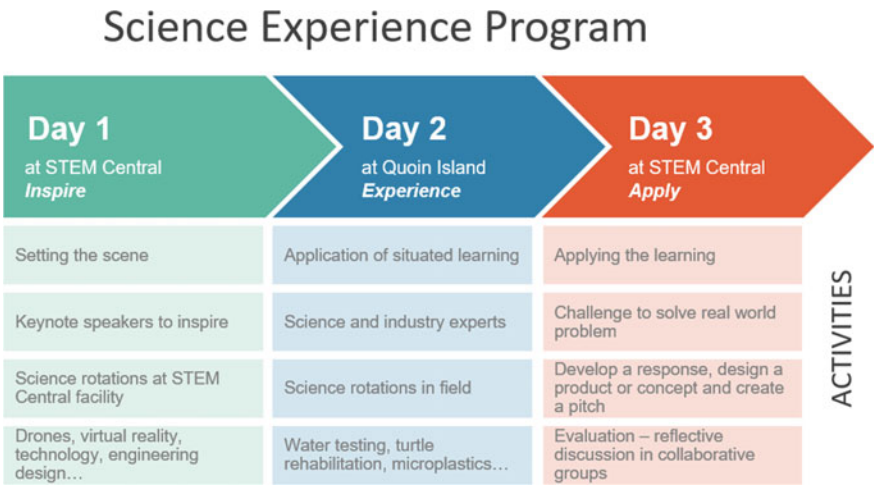

Fig. 8.1 Model for the 'Science Experience' Gladstone (Pfeiffer & Bradbury, in review)

experiences that are embedded within the sessions, students also embark on an excursion in one of the local wildlife rehabilitation centres. The full day excursion to Quoin Island Turtle Rehabilitation Centre allows the students to experience the work of the scientists and volunteers at the turtle hospital. The model developed for this location allows for STEM learning while immersed in the action or experience. Figure 8.1 demonstrates how the programme allows students to be inspired (through contextual keynote experts), experience and apply the concepts (through authentic experiences in a situated learning approach), and then apply the concepts they are immersed in (in a collaborative, social setting). Pairing outside the classroom learning environments with curriculum-based concepts in this active and collaborative way can increase students understanding of skills for future STEM careers.

What Do the Case Studies Tell Us?

The purpose of STEM Central was to establish a contemporary STEM facility in Gladstone to address the national (and international) STEM crisis at the local level for the benefit of the Gladstone community. STEM Central has developed a physical space and associated educational programme aimed at upskilling teachers, inspiring school students and engaging the Gladstone community in a future fuelled by STEM knowledge. Therefore, in its design, STEM Central has brought together University Academics, teachers, school children, industry, and the wider community to enhance the understanding of STEM. The project continues to provide local teachers with the necessary support to effectively engage students with STEM opportunities in a hands-on problem-based learning approach which is critical to addressing the STEM crisis.

Year 3 and 4 Teacher PD

Although this project was based on a small sample of teachers in a specific region of Queensland, the results from this research provide opportunity for broader applications. When analysing the approach to the PD design, one of the key components included industry connections with school stakeholders. This study highlights an embedded space that teachers attended collectively, however, school–industry partnerships forming collaborative spaces where educators collectively share practice and collaboratively work on their practice are possibilities for pedagogical development. Additionally, further research relating to the STEM Central space may allow for university and industry partners to see the possibility for similar design and spaces in other locations. The most effective PD relates to teachers working collaboratively, in watching each other's classes through the eyes of students, and modelling high impact practice (Caplan, et al., 2016). The research reported in this project did provide locally based, regional teachers with the opportunity to work collaboratively, with the hope that the teachers would then implement the modelled classroom practices to effectively engage students with STEM pedagogies in their primary science classrooms.

Science Experience

The Year 9 and 10 school students broaden their knowledge and skills through immersive STEM experiences and engaging with university, school, and industry partners including BOP Industries, Quoin Island Retreat, Tangaroa Blue, Coastal Marine Ecosystems Research Centre (CMERC), Harbour Watch, Gladstone Ports Corporation, and academics with expertise in drones and VR. The 'Science Experience' has been funded by ConocoPhillips up until 2019 when it was taken over by Santos. Both industries are gas plants and have locations in Gladstone. The challenges associated with this programme are that the programme is fully funded and as a result the spaces fill up fast with students from across the State of Queensland, meaning that many do not have the opportunity to attend. Successes of this programme in Gladstone include the strong university–school–industry partnerships that allow the programme to have a rich local context. Each of the partners contributes to the context and hands-on activities provided to the student participants while also learning about STEM in context from one another.

Future Considerations

STEM Central is a 'place, space, and face' for STEM education in regional Queensland. The future directions of the facility, programmes, and partnerships will continue

to evolve and change. During 2020–2023, the *Buraligim Weiber* programme ('place of learning') has been developed and implemented to increase Year 3 and Year 4 Indigenous students' scientific inquiry skills through a student-centred contextual programme. The programme is a university–school–industry partnership and centres around connections to the land and the sea.

Another possible future direction is in the hydrogen and clean energy area. Gladstone is fast becoming Queensland's energy hub with many projects around this sector recently announced. In 2021, CQUniversity employed a Professor of Hydrogen and Clean Energy to develop a Hydrogen Research Centre, and the building of a School of Manufacturing concluded in 2022. This year a report conducted by Questacon, a national science organisation in 2019, found that STEM Central is core to the relationships and activity in the Gladstone local community. Figure 8.2 shows the network of STEM connections across Gladstone and illustrates this central position that STEM Central holds.

The projects discussed previously provide further opportunities for STEM Central to lead the education of schools and the wider community in partnership with industry.

As with any partnership, sustainability is a future consideration. Often when the key driver moves on, projects tend to lose momentum. STEM education in Gladstone has attracted attention from the Queensland State Government by providing funding through the Queensland Office of the Chief Scientist for a Partner Up Queensland Science and Innovation network coordinator. In addition, the establishment of a STEM Hub network several years ago provides for the continuation of the programmes and partnerships in this regional location. For STEM Central, sustainability is being addressed through the development of a handbook or user manual for

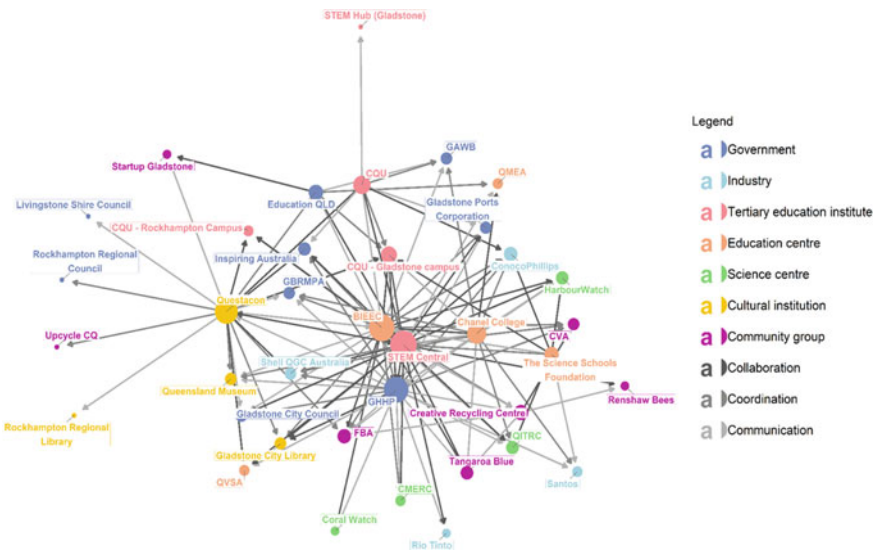

Fig. 8.2 Network of STEM connections across Gladstone (Questacon, 2022)

the space and resources as well as providing information sessions where potential users have the opportunity to be immersed in some of the programmes, resources, and networking opportunities. Utilising a community of practice model by not only showing people how the space and resources can be used but also inviting people to contribute to the development by using their imagination for their own contexts increases the outreach and outcomes of partnerships both vertically and horizontally.

Conclusion

The STEM crisis involves a shortage of students—the next generation, who will be responsible for our futures—studying Science, Technology, Engineering, and Mathematics. Intervention to stimulate interest and capacity for students to acquire the necessary aptitudes is urgently needed. Investment into Science, Technology, Engineering, and Mathematics (STEM) education and research has been recognised as critical to the future success and growth of the country as STEM is vital to all aspects of the nation's growth. There is substantial international and national research that has reinforced the requirement for investment in STEM education and research. STEM education must be relevant, engaging, and innovative to ensure that future generations are well equipped to face an increasingly competitive global economy as new technologies and industries emerge. In addition to the National STEM organisations, visits from local community groups and education providers such as local playgroups, early childhood centres, disability groups and school holiday programme providers reflect the ways in which this novel school–university–industry partnership is succeeding in not only responding to policy requirements but by also providing such groups with a unique opportunity of free access to a contemporary STEM facility and resources. Groups that have attended STEM Central have expressed their appreciation at being able to access such resources and programmes locally and the opportunities that it provides for their clients, students, families to understand STEM concepts through hands-on activities. Through university–school–industry partnerships, STEM Central is providing a 'place, space, and face' for STEM education in the Gladstone region.

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