Australian Government

Questacon
The National Science and Technology Centre

The STEM Learning Ecosystem: A 2019 Snapshot

Gladstone and Rockhampton
Central Queensland

Produced by Questacon – The National Science and Technology Centre,
A Division of the Department of Industry, Science and Resources

This report is based on Questacon-commissioned research conducted by ARTD Consultants.

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Key definitions

STEM

STEM education is a term used to refer collectively to the teaching of the disciplines within its umbrella – science, technology, engineering and mathematics – and also to a cross-disciplinary approach to teaching that increases student interest in STEM-related fields and improves students' problem solving and critical analysis skills.[1]

STEM Learning Ecosystem

A STEM Learning Ecosystem encompasses schools, tertiary institutions, industry programs, community settings such as after-school programs, science centres, and museums, and informal experiences in a variety of environments that together constitute a rich array of learning opportunities for young people and communities.[2]

Informal STEM providers

Organisations or groups that provide STEM learning across a multitude of designed settings and experiences outside of the formal classroom.[3]

Formal STEM providers

Organisations or groups that provide STEM learning activities that meet designed curriculum outcomes and are delivered as part of formal schooling from Foundation to Year 12.[4]

Questacon's National Presence Strategy

Questacon's National Presence Strategy aims to contribute to STEM capability nationally, and to support STEM learning ecosystems in specific regions through a place-based, sustained and cooperative approach to STEM engagement. The approach guides all our activities with a focus on STEM leadership, collaboration, connections and capacity-building to achieve an enduring impact.

[1] Education Council of Australia (2015) National STEM school Education Strategy, 2016-2026, www.educationcouncil.edu.au
[2] Adapted from Traphagen, K. and Traill, S. 2014 *Working paper: How cross-sector collaborations are advancing STEM learning*. The Noyce Foundation. Available from: https://smile.oregonstate.edu/sites/smile.oregonstate.edu/files/stem_ecosystems_report_execsum_140128.pdf (accessed 30/07/2021)
[3] Adapted from Centre for Advancement of Informal Science Education website https://www.informalscience.org/what-informal-stem-learning (accessed 13/12/2021)
[4] Adapted from Department of Education Skills and Employment website https://www.dese.gov.au/australian-curriculum (accessed 13/12/2021)

Executive summary

Questacon, Australia's National Science and Technology Centre, has been inspiring young people, families and educators through engagement with science, technology and innovation for 30 years in our Canberra Centres and around Australia. Questacon has a rich history of bringing innovative STEM experiences to communities in Queensland and forging relationships with other STEM providers.

We commissioned this study to create a snapshot of the STEM learning ecosystem in Central Queensland, looking at the Gladstone and Rockhampton regions. The study was also conducted in 2 other focus regions: the Northern Territory and Tasmania. The study aimed to:

- build our understanding of the STEM learning ecosystem
- inform our engagement with regional stakeholders
- provide a baseline for a future evaluation of Questacon's National Presence Strategy.

Questacon's National Presence Strategy

Our *National Presence Strategy* (NP Strategy) aims to contribute to STEM capability nationally, and to support STEM learning ecosystems in specific regions through a place-based approach to STEM engagement. It represents a shift in focus for Questacon from delivering primarily one-off inspirational STEM experiences to a model equally focused on sustained, collaborative engagement to achieve an enduring impact.

Under the NP Strategy, Questacon will not only measure success by the uptake or outcomes of its individual programs but will also measure our capacity to support and connect to other providers, experiences and resources in the STEM learning ecosystem.

A learning ecosystem approach acknowledges the multiple contexts for learning in and out of school, online, at home and in daily life. It promotes collaboration and connected learning opportunities and pathways to equip young people and communities for the future.

(Adapted from https:stemecosystems.org)

What we did

The study focused on the collective role of organisations in equipping young people for the future, informal STEM providers and their interaction with formal education.

In Gladstone and Rockhampton, we collected a range of data and information using 2019 as a reference year (TABLE 1). Limitations of this study included the low response rate to surveys impacting the ability to generalise and disaggregate findings.

TABLE 1 DATA COLLECTED IN GLADSTONE/ ROCKHAMPTON

Data source	Areas of inquiry	Data (Response rate)
Informal STEM providers survey	STEM vision, activities, and connections	12 (Unknown)
School survey	STEM capacity, activities and connections	19 (25%,N=76 schools)
Stakeholder interviews	Regional STEM priorities, strengths and challenges	17 (94%, N=18 selected interviewees)

Questacon's framework for measuring the STEM learning ecosystem

Questacon drew on mature ecosystem models[5] and research[6] to create a framework for the study design and synthesis. We identified 5 dimensions for STEM provider attributes in a STEM learning ecosystem. Drawing on systems theory[7,8] we then developed a rubric to assess the resilience of the STEM learning ecosystem. Here we have categorised the resilience of a STEM ecosystem as *individual, interactive*, or *interconnected*, as determined by indicators in each dimension (**FIGURE 1**).

FIGURE 1 QUESTACON STEM LEARNING ECOSYSTEM DIMENSIONS AND RUBRIC

Dimension	STEM learning ecosystem resilience scale		
	Individual	**Interactive**	**Interconnected**
Shared vision *Shared goals are developed based on the communities' needs, assets and interests*	**Few STEM providers understand or value** shared goals for STEM	**A moderate number of STEM providers understand and value** shared goals for STEM	**Most STEM providers understand and value** shared goals for STEM
Capacity and resources *STEM professionals and organisations have the resources, practices and tools to contribute to a robust STEM learning ecosystem*	**Limited capacity** and resources across organisations	**Moderate capacity** and resources across organisations	**Strong capacity** and resources across organisations
Diversity and density of STEM learning experiences *STEM learning experiences are accessible, connected and offered in diverse learning environments*	**Limited** range and coverage of experiences to meet diverse community/ region needs	**Moderate** range and coverage of experiences to meet diverse community/ region needs	**Wide** range and coverage of experiences to meet diverse community/ region needs
Relationships *Cross-sector connections are fostered to realise a collective vision of STEM for young people*	**One to one** connections between providers	**One to many** connections between providers	**Many to many** connections between providers
Learning pathways *Diverse, connected learning pathways enable young people to become engaged, knowledgeable and skilled in STEM as they progress through childhood into early adulthood*	**Weak pathway** connections and visibility across learning settings	**Moderate pathway** connections and visibility across learning settings	**Strong pathway** connections and visibility across learning settings

[5] https://stemecosystems.org/

[6] Traphagen, K. and Traill, S. 2014 *Working paper: How cross-sector collaborations are advancing STEM learning*. The Noyce Foundation. Available from: https://smile.oregonstate.edu/sites/smile.oregonstate.edu/files/stem_ecosystems_report_execsum_140128.pdf (accessed 30/07/2021); Vance S et al 2016 *Designing for Success: Developing a STEM Ecosystem*. University of San Diego; Hannon V et al 2019 Local learning ecosystems: emerging models, Innovation Unit, WISE

[7] Innovation Ecosystem Maturity. I do not believe in comparing different… | by Monika Rozalska-Lilo | CREATORS | Medium

[8] Acaroglu, Leyla 2017 *Tools for systems thinkers: 6 fundamental concepts of systems thinking* available on https://medium.com/disruptive-design/tools-for-systems-thinkers-the-6-fundamental-concepts-of-systems-thinking-379cdac3dc6a (accessed 4/12/2021)

What we found

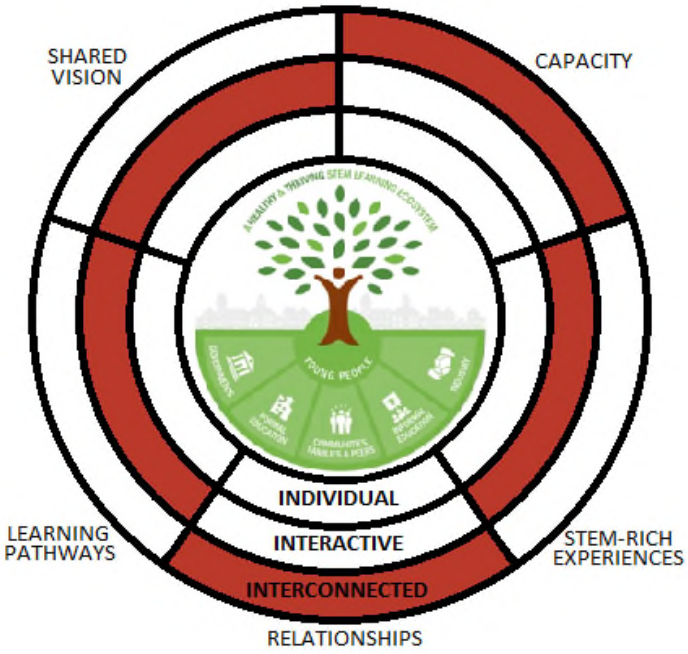
Overall, the study findings indicated an *interactive* STEM learning ecosystem in Gladstone/Rockhampton. The dimensions of *shared vision, diversity and density of STEM rich-experiences* and *learning pathways* indicated an *interactive* ecosystem. The dimensions of *capacity* and *relationships* indicated an *interconnected* ecosystem.

Differences in the STEM learning ecosystems between Gladstone and Rockhampton were difficult to distinguish because of the small sample and overlap in the organisations operating in both regions. The Gladstone STEM learning ecosystem appeared stronger and more interconnected because of the number and diversity of identified providers, leadership, and mechanisms for collaboration and coordination.

A high density and diversity of providers and STEM experiences were available for schools and communities. A range of formal initiatives to strengthen STEM pathways were found. However, findings suggested a missing strategic connection between informal providers and schools that could support better targeting and uptake of informal learning opportunities.

FIGURE *2* outlines the high level synthesised findings for each ecosystem dimension and whether it points to an *individual, interactive*, or *interconnected* STEM learning ecosystem.

FIGURE 2 ASSESSMENT OF THE STEM LEARNING ECOSYSTEM IN GLADSTONE/ ROCKHAMPTON



SHARED VISION

- Common goals were identified and, in Gladstone, a history of joint planning.
- Informal providers and schools had limited overlap in strategic areas of focus.
- Informal providers aspired to better align their activities and priorities with schools.

CAPACITY AND RESOURCES

- 43 diverse STEM providers identified with a presence in Gladstone or Rockhampton.
- Based on our small sample of schools (N=18), schools were positive about their STEM capacity and support received.

DIVERSITY AND DENSITY OF STEM-RICH EXPERIENCES

- In and out of school STEM experiences were offered across age cohorts and regions.
- Early childhood and Years 11 and 12 appeared less catered for.
- Reach was not able to be ascertained; but half of the surveyed schools (N=18) received a STEM incursion or excursion in a typical year.

RELATIONSHIPS

- Many informal providers were connected within Gladstone and to a lesser extent Rockhampton.
- Similarly, schools had formal cluster networks.
- The Gladstone learning ecosystem appeared richer and more connected than Rockhampton.
- Some providers had limited awareness of other providers and a strong appetite for increased collaboration.

LEARNING PATHWAYS

- Formal STEM learning pathways that connected schools, tertiary institutions and industry were identified.
- Pathways between school and informal learning experiences presented challenges for schools and providers.

What next

This snapshot of the STEM learning ecosystem in Gladstone/Rockhampton region represented a typical year pre-pandemic, and provided a benchmark for understanding, and tracking changes in, the STEM learning environment. While the Study had limitations, participating informal providers, schools and other stakeholders gave valuable data and insights.

There were several emerging opportunities from this Study.

- Engaging with regional stakeholders in the spirit of sharing and collaboration
  - Confirming indicative findings and exploring the value and potential use of the baseline for national and regional stakeholders
  - Exploring whether stakeholders consider a STEM learning ecosystem approach useful
  - Discussing the main opportunities and challenges to strengthen the STEM learning ecosystem
  - Facilitating connections and learning between regions.
- Shaping Questacon's practice and focus
  - Defining outcomes and activities for the next 6 or 12 months
  - Considering how our own practice is contributing to the 5 learning ecosystem dimensions
  - Placing a greater emphasis on understanding specific local needs and interests
  - Working with state and regional authorities and partners
  - Investing in tailored opportunities with multiple touchpoints to deepen engagement and outcomes
  - Sharing practice with other STEM providers.
- Progressing thinking about learning ecosystem concepts and principles to strengthen practice and outcomes
  - Testing if applying place-based, collaborative practice and a focus on the ecosystem leads to greater impact
  - Promoting the need for further research into STEM learning ecosystem theory and application in Australian settings.

Introduction

Questacon is Australia's National Science and Technology Centre. Questacon's vision is *a better future for all Australians through engagement with science, innovation and technology*. Young people are at the heart of this vision as Australia's future workforce, its future leaders and global citizens. Questacon has been inspiring young people, families and educators through STEM for 30 years, delivering innovative STEM experiences in our Canberra Centres and around Australia. Questacon has a rich history of bringing innovative STEM experiences to communities in Queensland and forging relationships with other STEM providers.

Questacon has embarked on a new National Presence Strategy (NP Strategy) aimed at working collaboratively to cultivate Australian STEM learning ecosystems; in Tasmania, the Northern Territory, and Central Queensland.

A STEM learning ecosystem encompasses a range of actors and settings - schools, tertiary institutions, industry programs, community settings such as after-school programs, science centres, and museums, and informal experiences in many environments that together constitute a rich array of learning opportunities for young people and communities.[9]

According to the STEM Learning Ecosystems Community of Practice[10], a robust STEM learning ecosystem has the potential to:

- Design and connect STEM learning opportunities in school, out of school, online, at home and in daily life
- Ensure young people have opportunities to engage in STEM learning, including under-represented groups
- Equip all STEM educators to understand the multiple learning contexts of young people and lead them in active, collaborative and rigorous learning
- Ensure parents and families have capacity to support their children's STEM learning and engagement.

Questacon's NP Strategy represents a shift in focus for Questacon from delivering primarily one-off inspirational STEM experiences to a model equally focused on sustained, collaborative engagement to achieve an enduring impact.

The NP Strategy is trialling whether a STEM learning ecosystem approach offers a sound conceptual and practical framework to guide Questacon and other organisations' regional investments in STEM engagement.

ACTORS IN A STEM LEARNING ECOSYSTEM

[9] Adapted from Traphagen, K. and Traill, S. 2014 *Working paper: How cross-sector collaborations are advancing STEM learning*. The Noyce Foundation. Available from: https://smile.oregonstate.edu/sites/smile.oregonstate.edu/files/stem_ecosystems_report_execsum_140128.pdf (accessed 30/07/2021)

[10] https://stemecosystems.org/

Study purpose

Under the NP Strategy, Questacon will not only measure success by the uptake or outcomes of its individual programs but will also measure our capacity to support and connect to other providers, experiences and resources in the learning ecosystem.

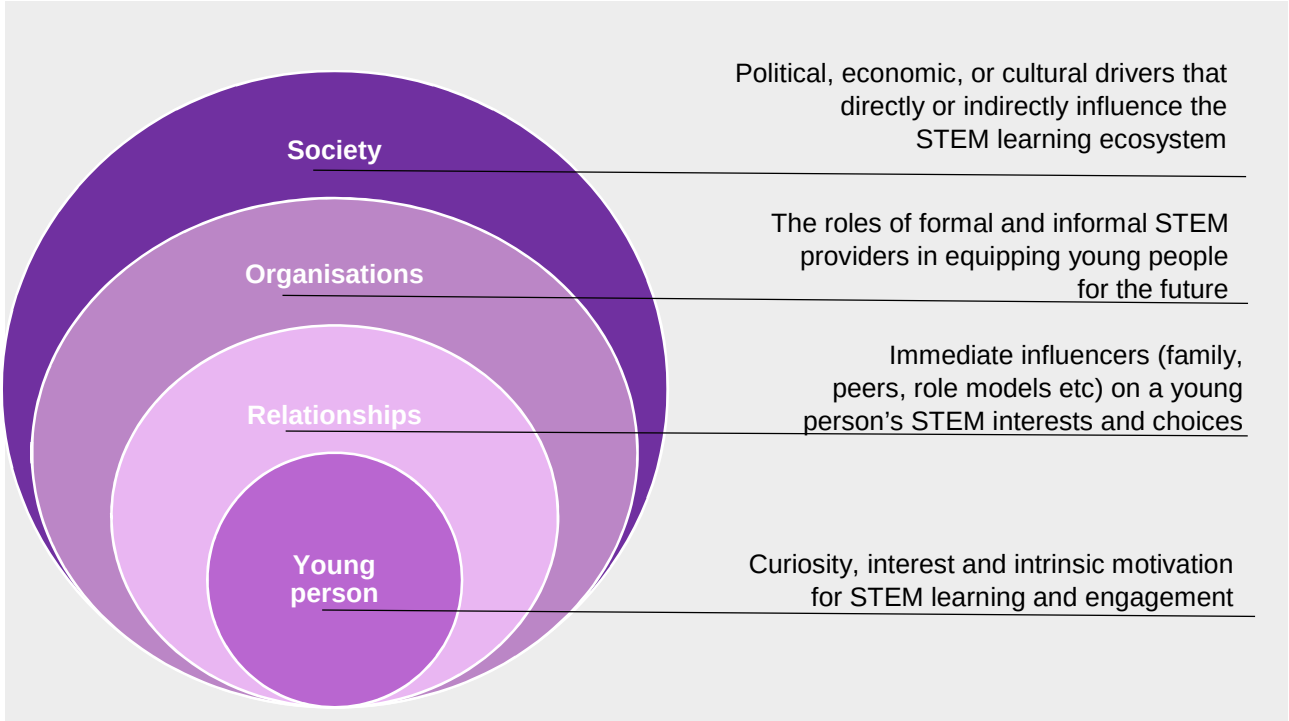
This Baseline Study was commissioned to inform Questacon's understanding of STEM learning in Gladstone and Rockhampton and 2 other focus regions; Northern Territory and Tasmania. It aimed to:

- Develop our understanding of STEM learning provision and identify how best to contribute to STEM learning and capacity
- Provide a benchmark for a future evaluation of the NP Strategy
- Explore the benefits of applying a learning ecosystem model to strategy implementation and impact measurement.

Applying a learning ecosystem perspective

Building on Bronfenbrenner's ecological model of child development[11], a learning ecosystem model recognises that learning potential is shaped by the interaction between a young person and their environment. The model blurs the traditional boundaries between formal and informal learning and recognises the collective role individuals, organisations and society play in equipping young people for lifelong learning and the future (**FIGURE 3**).[12]

FIGURE 3 APPLYING AN ECOLOGICAL MODEL TO A STEM LEARNING ECOSYSTEM[13]



[11] Bronfenbrenner, Urie. 1979 *The Ecology of Human Development*. Harvard University Press
[12] Hannon, V. *et al*. 2019 *Local learning ecosystems: emerging models*, Innovation Unit, WISE
[13] Meador, Amy et al. (2016). *Comparing 2 National Organization-Level Workplace Health Promotion and Improvement Tools*, 2013-2015. Preventing chronic disease. 13. 10.5888/pcd13.160164.

Baseline study design

This study aimed to explore the strengths and opportunities in the STEM learning ecosystem in Gladstone and Rockhampton using 2019 as a baseline reference year.

The study focused on the role of STEM learning providers in creating STEM learning opportunities and pathways for young people and communities. Specifically, the role of informal STEM providers and their interaction with formal education.

Questacon drew on mature learning ecosystem models[14] and research[15] to create a framework for the study design and data analysis (See **FIGURE 4** and **TABLE 2**). We identified 5 dimensions and associated measures for STEM provider attributes in a STEM learning ecosystem:

1. Shared vision
2. Capacity and resources
3. Diversity and density of STEM learning experiences
4. Relationships
5. Learning pathways

Drawing on systems theory[16,17] we then developed a rubric to assess the resilience of STEM providers in the STEM learning ecosystem using the following maturity scale:

- **Individual** –organisations are internally-driven with limited understanding of or connections to the wider learning ecosystem
- **Interactive** – organisations are informed by their understanding of and connections to the wider learning ecosystem
- **Interconnected** – organisations are functioning as part of a complex and dynamic learning ecosystem.

We synthesised findings against the dimensions and then used the rubric to assess the dynamics of the learning ecosystem at a point in time (**FIGURE 5**). The rubric does not reflect a judgement about the capability of STEM providers in the region. Rather, it aims to measure overall resilience of the STEM learning ecosystem.

[14] https://stemecosystems.org/
[15] Traphagen, K. and Traill, S. 2014 *Working paper: How cross-sector collaborations are advancing STEM learning*. The Noyce Foundation. Available from: https://smile.oregonstate.edu/sites/smile.oregonstate.edu/files/stem_ecosystems_report_execsum_140128.pdf (accessed 30/07/2021); Vance S et al 2016 *Designing for Success: Developing a STEM Ecosystem*. University of San Diego; Hannon V et al 2019 Local learning ecosystems: emerging models, Innovation Unit, WISE
[16] Innovation Ecosystem Maturity. I do not believe in comparing different… | by Monika Rozalska-Lilo | CREATORS | Medium
[17] Acaroglu, Leyla 2017 *Tools for systems thinkers: 6 fundamental concepts of systems thinking* available on https://medium.com/disruptive-design/tools-for-systems-thinkers-the-6-fundamental-concepts-of-systems-thinking-379cdac3dc6a (accessed 4/12/2021)

FIGURE 4 QUESTACON'S STEM LEARNING ECOSYSTEM DIMENSIONS AND RUBRIC

Dimension	STEM learning ecosystem resilience scale		
	Individual	**Interactive**	**Interconnected**
Shared vision *Shared goals are developed based on the communities' needs, assets and interests*	**Few STEM providers understand or value** shared goals for STEM	**A moderate number of STEM providers understand and value** shared goals for STEM	**Most STEM providers understand and value** shared goals for STEM
Capacity and resources *STEM professionals and organisations have the resources, practices and tools to contribute to a robust STEM learning ecosystem*	**Limited capacity** and resources across organisations	**Moderate capacity** and resources across organisations	**Strong capacity** and resources across organisations
Diversity and density of STEM learning experiences *STEM learning experiences are accessible, connected and offered in diverse learning environments*	**Limited** range and coverage of experiences to meet diverse community/ region needs	**Moderate** range and coverage of experiences to meet diverse community/ region needs	**Wide** range and coverage of experiences to meet diverse community/ region needs
Relationships *Cross-sector connections are fostered to realise a collective vision of STEM for young people*	**One to one** connections between providers	**One to many** connections between providers	**Many to many** connections between providers
Learning pathways *Diverse, connected learning pathways enable young people to become engaged, knowledgeable and skilled in STEM as they progress through childhood into early adulthood*	**Weak pathway** connections and visibility across learning settings	**Moderate pathway** connections and visibility across learning settings	**Strong pathway** connections and visibility across learning settings

Using the Study for a future NP Strategy evaluation

The synthesised baseline findings will be a point of comparison for a future evaluation to assess:

- Questacon's contribution to STEM learning ecosystem resilience and outcomes
- to what extent Questacon has reoriented its own way of working and relationships towards learning ecosystem principles
- whether an ecosystem approach with sustained and collaborative engagement delivers a more enduring impact.

A range of data sources would be used including repeating elements of the baseline study and a synthesis of Questacon data on our reach, engagement and program outcomes.

TABLE 2MEASURING THE ROLE OF STEM PROVIDERS IN STEM LEARNING ECOSYSTEMS[18]

DIMENSION	Shared Vision	Capacity and Resources	Diversity and density of STEM-rich experiences	Relationships	Learning pathways
OUTCOME	*Shared goals are developed based on the communities' needs, assets and interests*	*STEM professionals and organisations have the resources, practices and tools to contribute to a robust STEM learning ecosystem*	*STEM learning experiences are accessible, connected and offered in diverse learning environments*	*Cross-sector connections are fostered to realise a collective vision of STEM for young people*	*Diverse, connected learning pathways enable young people to become engaged, knowledgeable and skilled in STEM as they progress through childhood into early adulthood*
MEASURES	• Perceptions of a shared vision • Shared strategic focus areas • Government/industry policies, plans and investment	• Number and diversity of informal providers • Provider perceptions of collective capacity to meet informal STEM learning needs • Provider resources (people, time, money) • STEM teaching support, practices and resources in schools	• Range of school and community-based STEM experiences targeting all ages • Equitable reach of experiences • Extra-curricular activities in school • Educator STEM professional learning opportunities • Digital and in-person delivery modes offered	• Type and strength of connections between STEM providers • Cross-sector networks • Participation in formal networks • Informal provider and school attitudes on collaboration	• Formal and informal STEM pathway programs/ initiatives • Connections between school, out-of-school and post-school STEM programs

[18] Traphagen, K. and Traill, S. 2014

Study methods

The study employed a mixed methods design, which included surveys and interviews with STEM providers, teachers and informal STEM educators from government, industry and non-government organisations[19] and a document review. Key data sources are outlined in **TABLE 3**.

TABLE 3 STUDY DATA COLLECTION

Evidence source	Data collected		Response rate
Survey of informal STEM providers	12		Unknown
Survey of schools	19 (total)		25% (N=76 schools)
	Catholic	State	
Primary	8	5	
Secondary	3	3	
Stakeholder interviews	17 (total)		94% (N=18 selected interviewees)
Informal providers	14		
Formal education stakeholders	3		
Document review	Range of policy/strategy documents		n/a

Study Limitations

Limitations of this study included the low response rate to surveys impacting the ability to generalise and disaggregate findings.

Informal STEM provider survey

A snowballing technique, where the survey is distributed on by people sent the survey, was used to broaden the reach of the survey. It is not possible to know how many providers received an email survey invitation and a response rate cannot be calculated. There were also limitations being able to analyse the differences between Gladstone and Rockhampton due to the overlapping boundaries for STEM provider services between the regions.

Schools survey

The response rate from government schools was low (8 of the 60 invited schools), limiting our understanding of their operations, strengths and challenges. Although a similar number of responses were received from Catholic schools, these provide a more representative sample of the Catholic schools (11 of the 16 invited schools). The analysis does not distinguish between school respondents from different sectors.

[19] Allen, S. and Peterman, K. 2019 "Evaluating informal STEM education issues and challenges in context". In A.C. Fu, A. Kannan and R. J. Shavelson (Eds.) *Evaluation in Informal Science, Technology, Engineering and Mathematics Education. New Directions for Evaluation*, 161, 17-33

Key Findings

In Gladstone and Rockhampton, we collected a range of data and information using 2019 as a reference year. This snapshot of the STEM learning ecosystem represented a typical year pre-pandemic, and aimed to provide a benchmark for understanding, and tracking changes in, the STEM learning environment.

Limitations of this study included the low response rate to surveys and overlapping data between Gladstone and Rockhampton regions impacting the ability to generalise and disaggregate findings. While the Study had limitations, participating informal providers, schools and other stakeholders gave valuable data and insights.

The following sections are a synthesis of findings organised by the 5 dimensions and associated measures and highlight the identified strengths, gaps or challenges. We then applied the ecosystem resilience rubric using a scale of *individual, interactive* and *interconnected*.

FIGURE 5 highlights the key findings for each dimension and overall STEM learning ecosystem.

FIGURE 5 ASSESSMENT OF THE STEM LEARNING ECOSYSTEM DIMENSIONS AND RESILIENCE

SHARED VISION

- Common goals identified and, in Gladstone, a history of joint planning.
- Informal providers and schools had limited overlap in strategic areas of focus.
- Informal providers aspired to better align their activities and priorities with schools.

CAPACITY AND RESOURCES

- 43 diverse STEM providers identified with a presence in Gladstone and/or Rockhampton.
- Based on our small sample of schools (N=18), schools were positive about their STEM capacity and support received.

DIVERSITY AND DENSITY OF STEM-RICH EXPERIENCES

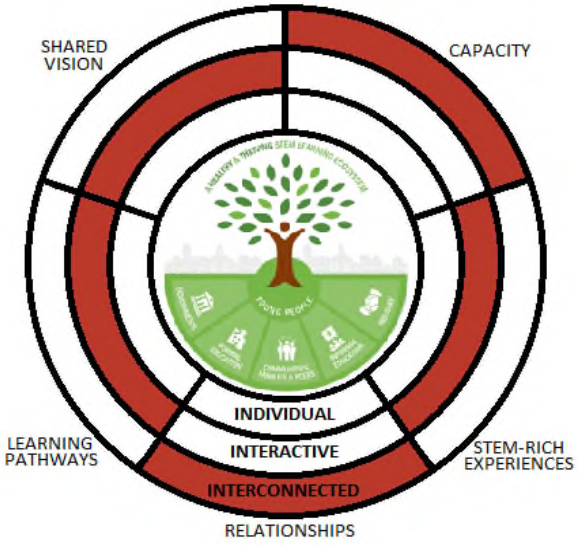
- In and out of school STEM experiences were offered across age cohorts and regions.
- Early childhood and Years 11 and 12 appeared less catered for.
- Reach was not able to be ascertained; but half of the surveyed schools (N=18) received a STEM incursion or excursion in a typical year.

RELATIONSHIPS

- Many informal providers were connected within Gladstone and to a lesser extent Rockhampton.
- Similarly, schools had formal cluster networks.
- The Gladstone learning ecosystem appeared richer and more connected.
- Some providers had limited awareness of other providers and a strong appetite for increased collaboration.

LEARNING PATHWAYS

- Formal STEM learning pathways that connected schools, tertiary institutions and industry were identified.
- Pathways between school and informal learning experiences presented challenges for schools and providers.



Shared Vision

SHARED GOALS ARE DEVELOPED BASED ON THE COMMUNITY'S NEEDS, ASSETS AND INTERESTS

A shared vision encourages buy-in from key actors within the learning ecosystem and the distribution of responsibility for learning among all sectors. Shared visions aimed at young people may include goals such as academic achievement, participation, and/or development of identity, interest, curiosity and passion [20]

KEY BASELINE MEASURES

- Perceptions of a shared vision amongst STEM providers
- Documented STEM policy/ strategy
- Evidence of shared strategic areas of focus

KEY FINDINGS

The presence of a shared vision for STEM indicated an 'interactive' ecosystem.

Informal providers described common goals and focus though a shared vision wasn't formalised.

Gladstone providers had a history of joint planning through a formal STEM Hub suggesting a collective mindset.

However, there was no obvious mechanism to share and align strategic goals and plans between informal STEM providers and schools.

STRENGTHS

Most informal providers, and to a lesser extent schools, perceived there was a shared vision for STEM.

Stakeholder interviews identified common and complementary visions for STEM around the theme of '*growing STEM engagement in the region*'. Informal providers demonstrated consistency in their strategic areas of focus. In Gladstone, a key group of informal providers engaged in joint planning and activities.

Interestingly, schools ranked '*more connected STEM providers and activities'* as their top area of focus and most reported success in this area. This suggests providers are positively disposed to collaboration.

Queensland's Department of education STEM strategy, '*Schools of the future*' provided STEM strategic direction and support for state schools.

IDENTIFIED GAPS OR CHALLENGES

Providers reported a major focus on addressing barriers to STEM opportunities but most reported limited success in this area.

Informal providers and schools tended to rank areas of strategic focus differently. No obvious mechanisms were identified for informal providers to align their activities and priorities with schools.

[20] National Research Council 2014. *STEM learning is everywhere: Summary of a convocation on building learning systems.* Washington DC: The National Academies

Shared Vision

Perceptions of shared vision

Most informal STEM providers (67%, N=12) but less than half of schools (47%, N= 17) believed there was a shared vision for STEM in their region.

Interviews with providers identified several complementary aspirational themes:

- A common view was a shared vision around growing STEM engagement in the region.
- Industry and university stakeholders also focused on an end goal to encourage students to further their STEM education with a view to careers and meeting local workforce needs.
- Others identified young people succeeding in life as the vision, such as through being adept at technology.
- Community engagement in STEM was also highlighted as a means to respect and protect the region's natural assets and improve liveability and prosperity for the community.

The well-connected providers in Gladstone tended to jointly plan, coordinate and deliver key aspects of their work with the other providers.

Documented policy/strategy

The Queensland Department of Education STEM strategy, Schools of the Future, aimed to:

- Lift STEM participation including girls and Aboriginal and Torres Strait Islander students
- Give every state school access to a specialist STEM teacher
- Ensure every state school offers the Digital Technologies curriculum, including coding and robotics
- Improve teacher capability through enhancing teacher readiness, professional development, scholarships, and mentoring by STEM champions.

At the infrastructure level, the Queensland Government was improving access to technology for state schools through better internet connectivity.

'Schools of the Future' priorities:

- *establishing STEM virtual academies, including the Queensland Coding Academy and the STEM Hub*
- *incubating the next generation of IT entrepreneurs*
- *fast tracking the implementation of the Digital Technologies curriculum, including coding and robotics programs.*

Evidence of shared areas of focus

Informal STEM providers and schools were asked to report their strategic STEM areas of focus from a pre-defined list of survey items. The extent of success was only asked to those who indicated the statement was a moderate to major focus for their organisation or group. (**FIGURE 6** and **FIGURE 7**).

A top focus area for informal providers and schools was '*Growing STEM engagement*' and most reported success in this area.

Informal STEM providers reported a focus and success on '*empowering'* and '*engaging STEM learners'*.

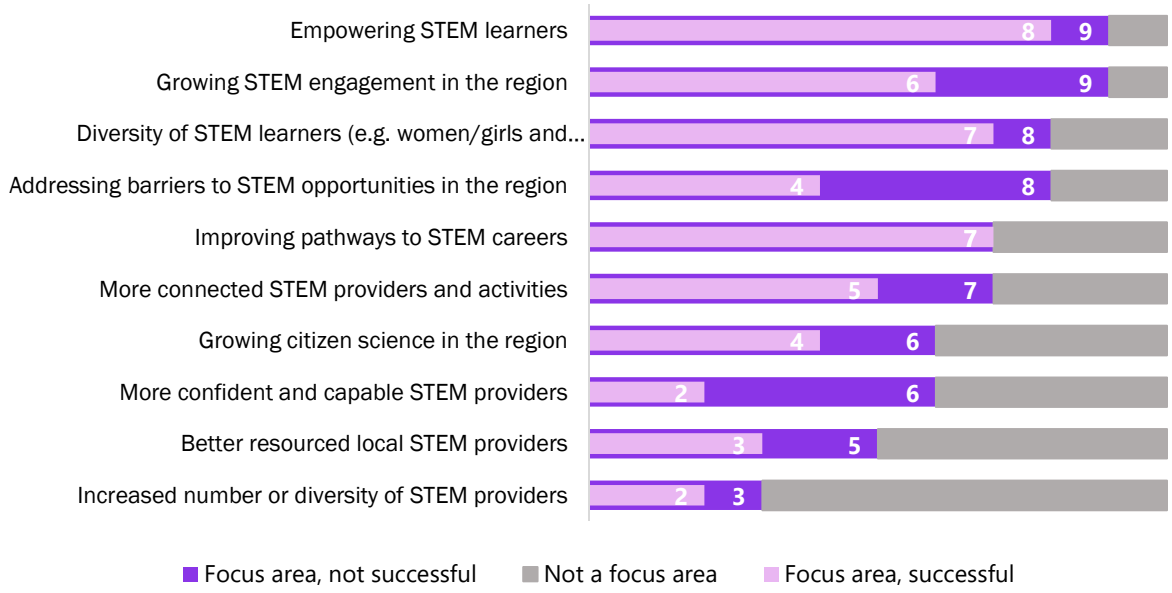
Strengthening of STEM providers themselves that is, capability, resources, number and diversity, was the lowest priority for informal providers.

Schools' focus and success in achieving '*more connected providers and activities*' suggests they valued connected learning experiences. '*More confident and capable STEM educators*' was also a focus for schools in which most of our sample of schools reported success.

'*Improving pathways to STEM careers*' was not an identified focus for most schools (one of 18 schools identified it as a focus area) but it was a successful focus area for informal providers.

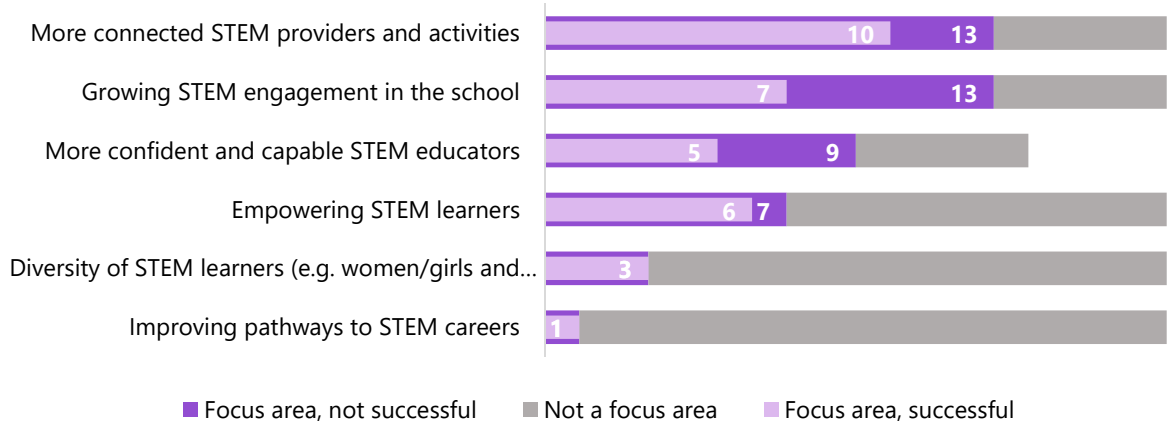
'*Addressing barriers to STEM opportunities in the region*' was a major focus and may be an ongoing priority as half of providers reported success.

FIGURE 6 INFORMAL PROVIDER STEM FOCUS AREAS IN 2019, AND LEVEL OF SUCCESS



Source: Informal STEM provider survey, 2020. N=12.

FIGURE 7 SCHOOLS STEM FOCUS AREAS IN 2019, AND LEVEL OF SUCCESS



Source: School survey. N=19.

Capacity and Resources

COLLECTIVE CAPACITY AND RESOURCES ARE ABLE TO MEET COMMUNITY NEEDS

STEM professional and organisations have the organisational and technical resources, practices and tools to support a robust STEM learning ecosystem

KEY BASELINE MEASURES

- Number and diversity of informal providers
- Provider resources
- Provider organisational strengths
- STEM teaching support, practices and materials in schools

KEY FINDINGS

Collective capacity and resources indicated an 'interconnected' ecosystem.

Forty-three diverse informal providers were identified with a presence in Gladstone or Rockhampton.

Based on our small sample (N=18), schools were positive about their STEM capacity and support received.

STRENGTHS

The diversity of informal STEM providers across government, industry, education, cultural institutions and non-government suggested strong collective capacity.

Surveyed schools (N=18) felt supported in STEM. They reported innovative STEM learning and teaching approaches. They offered extra-curricular STEM activities at school and valued the role of external providers.

Noting the small sample size of schools, more data would be needed to confirm these findings

IDENTIFIED GAPS OR CHALLENGES

Several informal providers and school representatives mentioned that limited resources affected the reach and number of activities they were able to offer.

Schools were time-poor and providers had limited planning capacity. Aligning programs to the needs of schools was an identified challenge (discussed further under **Learning Pathways**).

Capacity and Resources

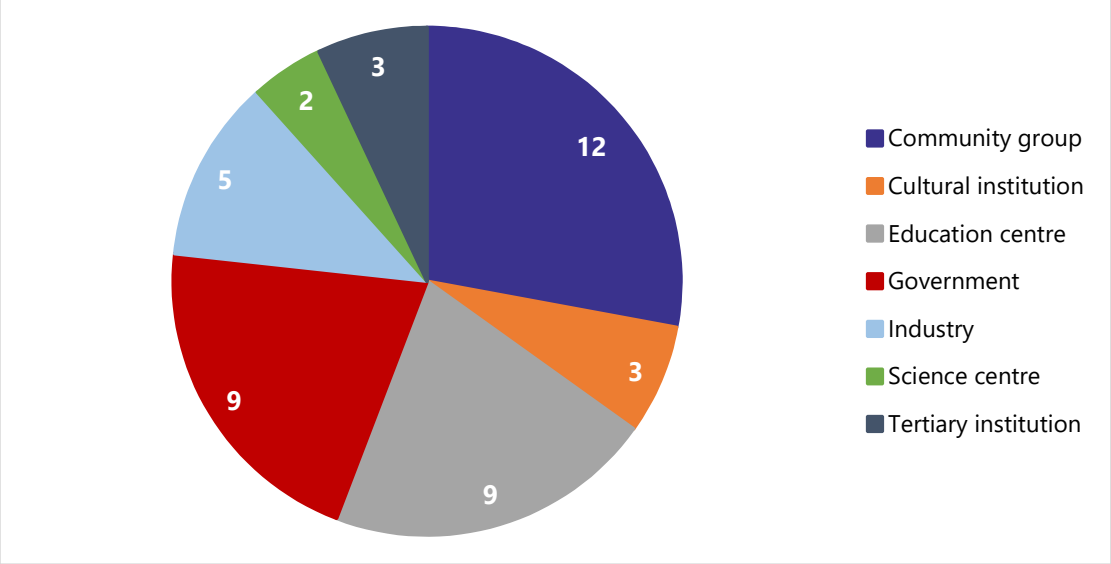
Number and diversity of informal providers

The study identified 43 STEM providers offering informal STEM experiences in Rockhampton or Gladstone regions (listed in **Appendix 1**). It is unclear how inclusive this list is of all informal STEM providers as the definition is broad and a formal registry of providers was not available.

Providers were diverse, including education centres, cultural institutions, environmental foundations/groups, government, and community organisations (**FIGURE 8**).

Around half of these organisations were local to Gladstone or Rockhampton and around half were national or state-based organisations with a presence in one or both of the regions.

FIGURE 8 NATIONAL, STATE AND LOCAL PROVIDERS OFFERING INFORMAL STEM ENGAGEMENT OPPORTUNITIES IN GLADSTONE AND ROCKHAMPTON IN 2019, BY PROVIDER TYPE



Notes: N=43 Sources: Names of STEM providers come from (a) respondents to the Baseline Informal STEM Providers Engagement Survey 2020, (b) STEM providers listed in the Baseline Informal STEM Providers Engagement Survey 2020, (c) STEM providers nominated by respondents in the Baseline Informal STEM Providers Engagement Survey 2020, (d) STEM providers identified during interviews with informal STEM providers, and (e) STEM providers listed as offering incursions or excursions in the Baseline Schools STEM Engagement Survey 2020. Notes: Providers only counted once.

Informal provider organisational strengths

Informal STEM providers offered a diversity of experiences to meet the needs of young people at different learning stages.

Interviews indicated that providers were using innovative and best practice approaches and were accessing a range of expertise at local and state level. STEM providers were able to capitalise on community natural assets and environmental attractions. Many community providers had an environmental focus, which facilitated citizen science projects and supported community environmental groups in both Gladstone and Rockhampton.

CQU's highly regarded informal STEM programs and facilities, built through strong industry partnerships, were also supporting other providers in the regions.

Several government authorities and institutions were also active in STEM engagement and education, such as the Gladstone Healthy Harbour Partnership, alongside a range of industry programs.

There were also strong connections between formal and informal STEM education through centres such as the Boyne Island Environmental Education Centre, whose core business is to offer school excursions and camps.

Provider resources (people, time, money)

Many providers mentioned resource constraints limiting the reach and range of their activities and their capacity to give opportunities with sufficient regularity. Providers aiming to recover costs through charging schools recognised this was a barrier to schools' participation including the direct and indirect costs such as travel.

As well as offering STEM programs, industry groups invested in STEM learning activities offered through community groups, associations, and universities.

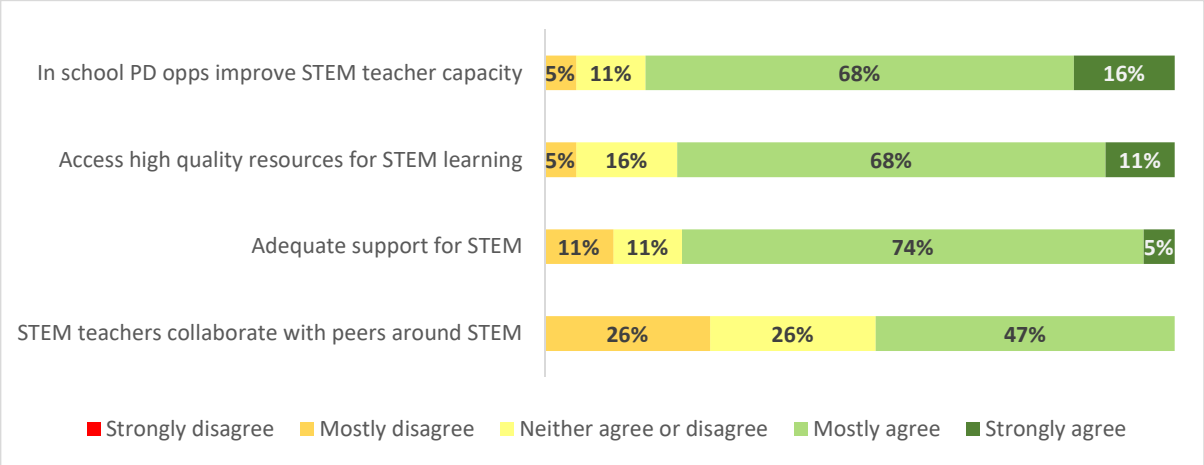
STEM teaching support, practices and resources in schools

Overall, a small number of schools (N=19) responded to the survey. These schools were positive in rating their school's STEM capacity, though the small sample size meant findings could not be generalised to all schools in the region.

Most schools (79%) reported that they had access to quality STEM resources and support in their school. Around half collaborated with other teachers around STEM (**FIGURE 9**). STEM professional development and student programs were valued by schools.

Most respondents also received in-school professional development that improved STEM teacher capacity (**FIGURE 9**). The Queensland government supported STEM professional learning opportunities to both primary and secondary school teachers.

FIGURE 9 STEM RESOURCES AND SUPPORTS IN SCHOOLS

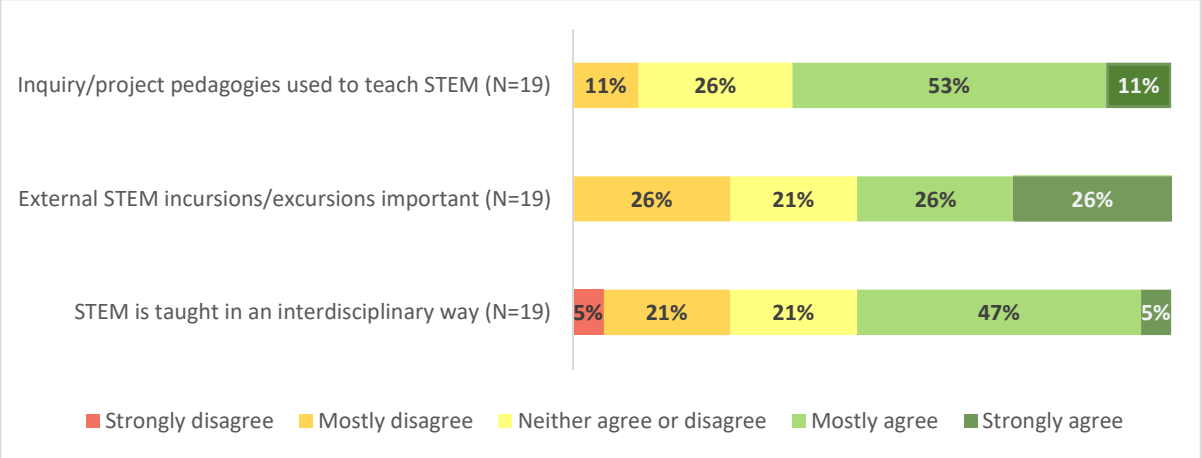


Notes: N=19 Source: Baseline Schools STEM Engagement Survey 2020

More than half of schools reported using inquiry- or project-based pedagogy to teach STEM (64%) and were teaching STEM in an interdisciplinary (or cross-curricular) way (52%) (**FIGURE 10**). These innovative teaching techniques can enhance STEM engagement and understanding, promote innovative thinking, and build 21st century skills that better prepare students for the future world of work[21,22,23].

Over half of teachers (58%) felt STEM subjects were in demand by students. Based on teacher perceptions, this could be an indicator of student interest in STEM or the quality of STEM teaching or other STEM opportunities in schools.

FIGURE 10 STEM LEARNING PRACTICES IN SCHOOLS



Notes: N=19 Source: Baseline Schools STEM Engagement Survey 2020

[21] Regional Australia Institute & National Broadband Network (2016). The future of work: setting kids up for success. Canberra, Regional Australia Institute.
[22] Foundation for Young Australians (2017). The New Basics: Big data reveals the skills young people need for the New Work Order. (pp.7)
[23] Office of the Chief Scientist (2015). Transforming STEM teaching in Australian primary schools: everybody's business. Canberra, Department of Industry, Innovation and Science.

Diversity and density of STEM-rich experiences

STEM LEARNING IS OFFERED IN DIVERSE ENVIRONMENTS, FOSTERING YOUNG PEOPLES' ACCESS TO MULTIPLE LEARNING EXPERIENCES

Ideally, there are "multiple access points that reflect the range of perspectives, backgrounds, and strengths of the diverse people who inhabit the learning ecosystem" [24]

KEY BASELINE MEASURES

- Range of school STEM incursion, excursions, and extra-curricular activities
- Range of community-based STEM experiences
- Equitable reach of STEM experiences
- Educator STEM professional opportunities

KEY FINDINGS

The diversity and density of STEM-rich experiences indicated an 'interactive' ecosystem.

Overall, the region offered a wide and diverse range of school and community-based STEM experiences for young people and the community.

STRENGTHS

In and out of school experiences were offered across all age cohorts in a range of settings.

Data from providers and schools identified 34 diverse informal providers delivering school incursions and excursions.

Seven providers offered community-based STEM experiences in 2019 including major annual events reaching large numbers of the community.

Based on our sample, Gladstone providers offered more experiences and some serviced Rockhampton.

IDENTIFIED GAPS OR CHALLENGES

Based on our small sample of schools (N=18), half of the schools received a STEM incursion or excursion in a typical year.

In our sample, there were fewer informal STEM programs and activities aimed at early childhood and later school years (Years 11 and 12), and educator professional learning.

Digital or virtual offerings were uncommon.

[24] Bevan, B., Garibay, C. and Menezes, S. 2018 *What is a STEM learning ecosystem?* Available from: https://www.informalscience.org/sites/default/files/BP-7-STEM-Learning-Ecosystem.pdf

Density and diversity of STEM-rich experiences

Range of school incursions, excursions[25] and extra-curricular activities

Thirty-four informal STEM providers delivered school-based incursions and excursions in 2019 (**FIGURE 11**). Most surveyed providers were Gladstone-based though some serviced both regions.

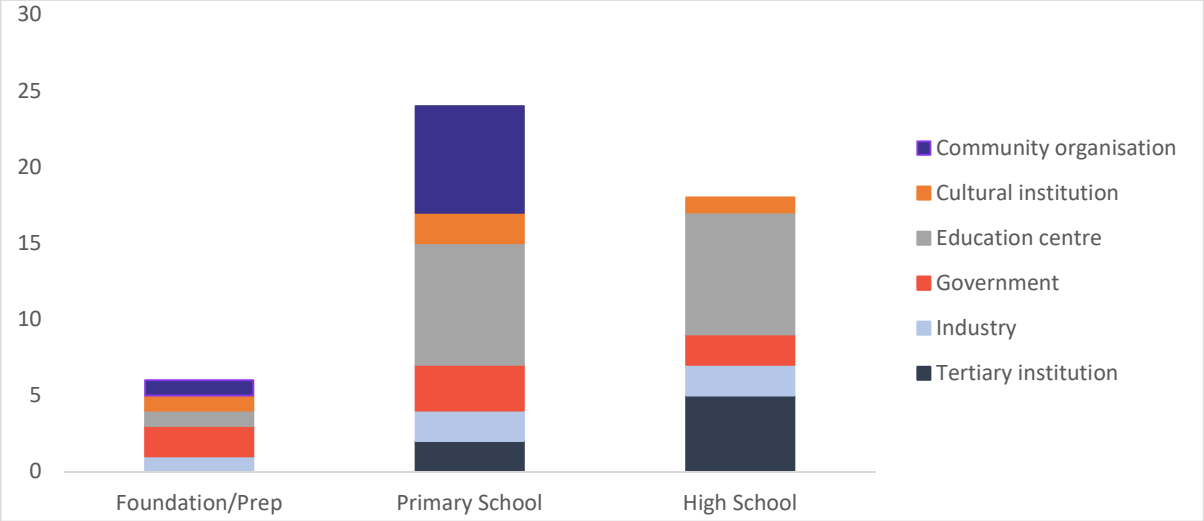
All age groups were catered for though less was offered for early childhood years. Providers confirmed that there was limited content available for foundation/prep and early years cohorts.

STEM Central at CQU Gladstone runs a range of STEM programs and events for teachers and students in-schools and at its custom-built STEM facility.

Most programs targeted Years 3-6 in primary and Years 7-8 in secondary school. Few programs targeted Years 11 and 12. Excursions included visits to cultural institutions, and education and science centres with permanent or temporary exhibition spaces.

66% of schools offered extra-curricular[26] STEM activities such as STEM clubs and after-school programs.

FIGURE 11 INFORMAL STEM ACTIVITIES IN 2019 BY TARGET GROUPS AND PROVIDER TYPE



N=34 providers. Source: Baseline Schools STEM Engagement Survey 2020; Baseline Informal STEM Providers Engagement Survey 2020

The Queensland Minerals and Energy Academy (QMEA), a joint initiative of the Queensland Resources Council and the Queensland Government; offers a range of programs connecting STEM experts with school groups.

[25] An incursion can be defined as an outside organisation visiting a school to deliver education during school hours (including virtual delivery) and an excursion can include students visiting a workplace, museum, university, or specialised educational centre. Source: Department of Education, Skills and Employment 2021 *Different kinds of STEM education initiatives*. Available from: https://www.dese.gov.au/australian-curriculum/national-stem-education-resources-toolkit/i-want-know-about-stem-education/different-kinds-stem-education-initiatives/ (accessed 16/09/2021)

[26] Extracurricular activities are optional student activities that occur outside of school hours managed and run by schools or external providers. Source: Department of Education, Skills and Employment 2021 *Different kinds of STEM education initiatives*. Available from: https://www.dese.gov.au/australian-curriculum/national-stem-education-resources-toolkit/i-want-know-about-stem-education/different-kinds-stem-education-initiatives/ (accessed 16/09/2021)

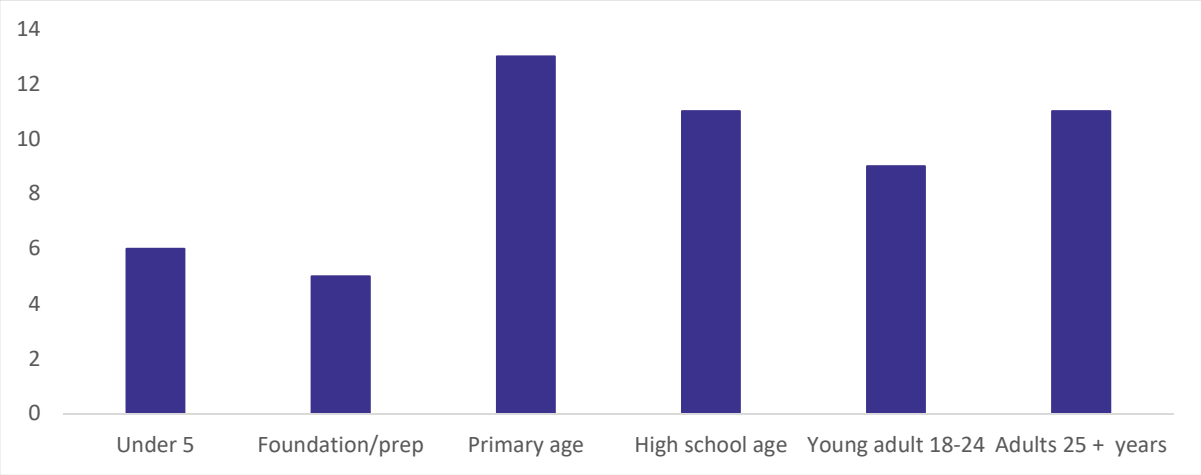
Range of community-based STEM experiences targeting all ages

Seven informal STEM providers delivered a total of 18 distinct activities in 2019. Most activities targeted primary followed by secondary aged children (**FIGURE 12**).

Activities included *First LEGO League*, 3D printing workshops, citizen science, events and festivals. Six STEM-based festivals were held in 2019, with providers hosting various activities; combined, these activities reached 48,029 people.

The Gladstone Harbour Festival is an annual multi-day event involving a wide array of contributors and participants. Over 16,000 people attended the event in 2019.

FIGURE 12 TARGET AGE GROUPS OF COMMUNITY STEM PROGRAMS IN 2019 (N=18 ACTIVITIES)



Source: Baseline Informal STEM Providers Engagement Survey 2020. Activities may target more than one age group.

Equitable reach of experiences

Geographic and demographic reach of STEM learning could not be determined, because of the low response to the school survey. Still, just over half of surveyed schools (53%, N=19) reported receiving a STEM incursion or excursion in a typical year.

The Virtual STEM Academy in Rockhampton provides many local STEM learning experiences.

For example, it partnered with Capricorn Caves to run a palaeontology challenge.

Digital or mixed mode (hybrid) delivery models have potential to extend activity reach and create sustained, personalised and innovative learning experiences[27]. In 2019, digital delivery of STEM programs was uncommon and few providers had existing digital capacity. One of the surveyed providers routinely delivered digital programs. This has likely shifted since 2019 given the digital pivot experienced by most sectors during the COVID-19 pandemic.

[27] Hannon V et al 2019 Local learning ecosystems: emerging models, Innovation Unit, WISE and Teach Online.CA: A New Pedagogy is Emerging, Contact North Canada. Available from: https://teachonline.ca/tools-trends/how-teach-online-student-success/new-pedagogy-emerging-and-online-learning-key-contributing-factor (accessed December 2021)

Educator STEM professional learning opportunities

63% of surveyed schools (N=18) reported that their teaching staff received STEM professional development in 2019.

The reach of professional learning for teachers was difficult to assess on the available evidence. 5 of the informal providers responding to our survey had delivered 7 occurrences of teacher professional learning total in 2019.

It was noted that teachers are time poor and teacher release is a barrier. The Queensland Department of Education's financial support for teacher professional development aimed to address these constraints.

Relationships

CROSS-SECTOR CONNECTIONS ARE FOSTERED TO REALISE A COLLECTIVE GOAL FOR STEM

Connections and collaboration across providers enable sharing of knowledge, practice, capacity and resources to enhance STEM learning provision and outcomes. Connected providers can also more effectively provide the stepping stones for young people navigating the STEM learning ecosystem through traditional schooling, out of school learning, and future study/careers [28]

KEY BASELINE MEASURES

- Type and strength of connections between STEM providers
- Informal provider and school attitudes on collaboration
- Cross-sector connections
- Formal networks

KEY FINDINGS

STEM provider relationships indicated an 'interconnected' ecosystem.

Informal providers reported several connections within and between Gladstone and Rockhampton.

The Gladstone learning ecosystem appeared richer and more connected than Rockhampton as a formal network of informal providers were working together regularly.

STRENGTHS

The STEM Hub in Gladstone promoted collaboration among several organisations. Interviewees pointed to the benefits of a well-resourced coordination function and active leadership for the network to flourish. The STEM Hub included representation of school educators.

Schools were also networked through cluster groups comprising cross-school representation suggesting further potential for interconnectedness.

Collaboration was enabled by strong relationships, high levels of trust and cross-sector networks.

IDENTIFIED GAPS OR CHALLENGES

Some surveyed providers had limited awareness of other organisations in the STEM learning ecosystem.

There was strong appetite for deepening collaboration and coordination in and across the regions.

Findings suggested that collaborating presented challenges for some informal providers and schools.

[28] Morrison, J. and Fisher, W. P. (2018) Connecting learning opportunities in STEM education: Ecosystem collaborations across schools, museums, libraries, employers and communities. Journal of Physics: Conference Series, 1065. Available from: https://iopscience.iop.org/article/10.1088/1742-6596/1065/2/022009

Relationships

Type and strength of connections between STEM providers

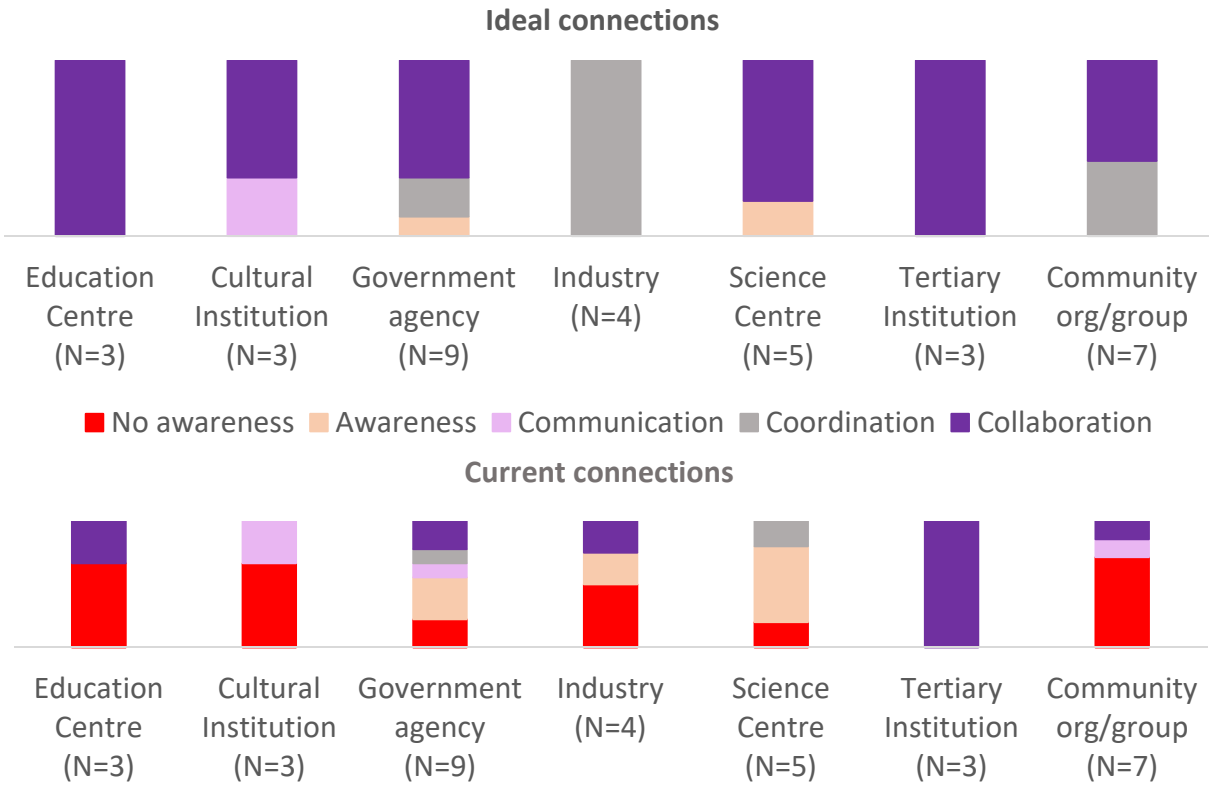
Informal provider survey respondents rated their current and ideal level of connection with 34 informal provider organisations that had been identified and listed in the survey. Responses were made against a scale of: 'No awareness', 'Awareness', 'Communication', 'Coordination' and 'Collaboration'.

FIGURE 13 presents the most common type of connection (the mode) for each listed provider reported by informal providers (N=12). Listed providers are de-identified and shown by type.

Collaboration with tertiary institutions was strong. Interviews confirmed that there was strong awareness, communication, coordination and collaboration across a group of interconnected providers. The graph shows that other providers had limited awareness of the wider STEM learning ecosystem.

Overwhelmingly, providers wanted to increase their level of coordination and collaboration with other providers suggesting a strong appetite for expanding the network of organisations who were working collaboratively and coordinating planning and activities.

FIGURE 13 CURRENT VS IDEAL LEVELS OF CONNECTIONS BETWEEN INFORMAL STEM PROVIDERS



NOTES N=12. Informal providers rated their current and ideal levels of connectedness with other providers against a list of 34 informal provider organisations using a scale of: 'No awareness', 'Awareness', 'Communication', 'Coordination' and 'Collaboration'. The most common type of connection (the mode) is shown with listed providers de-identified and shown by type. Source: Baseline Informal STEM Providers Engagement Survey 2020

Cross-sector networks

Organisations actively connecting through either communication, coordination or collaboration are presented in network maps for Gladstone and Rockhampton (**FIGURE 14** and **FIGURE 15**).

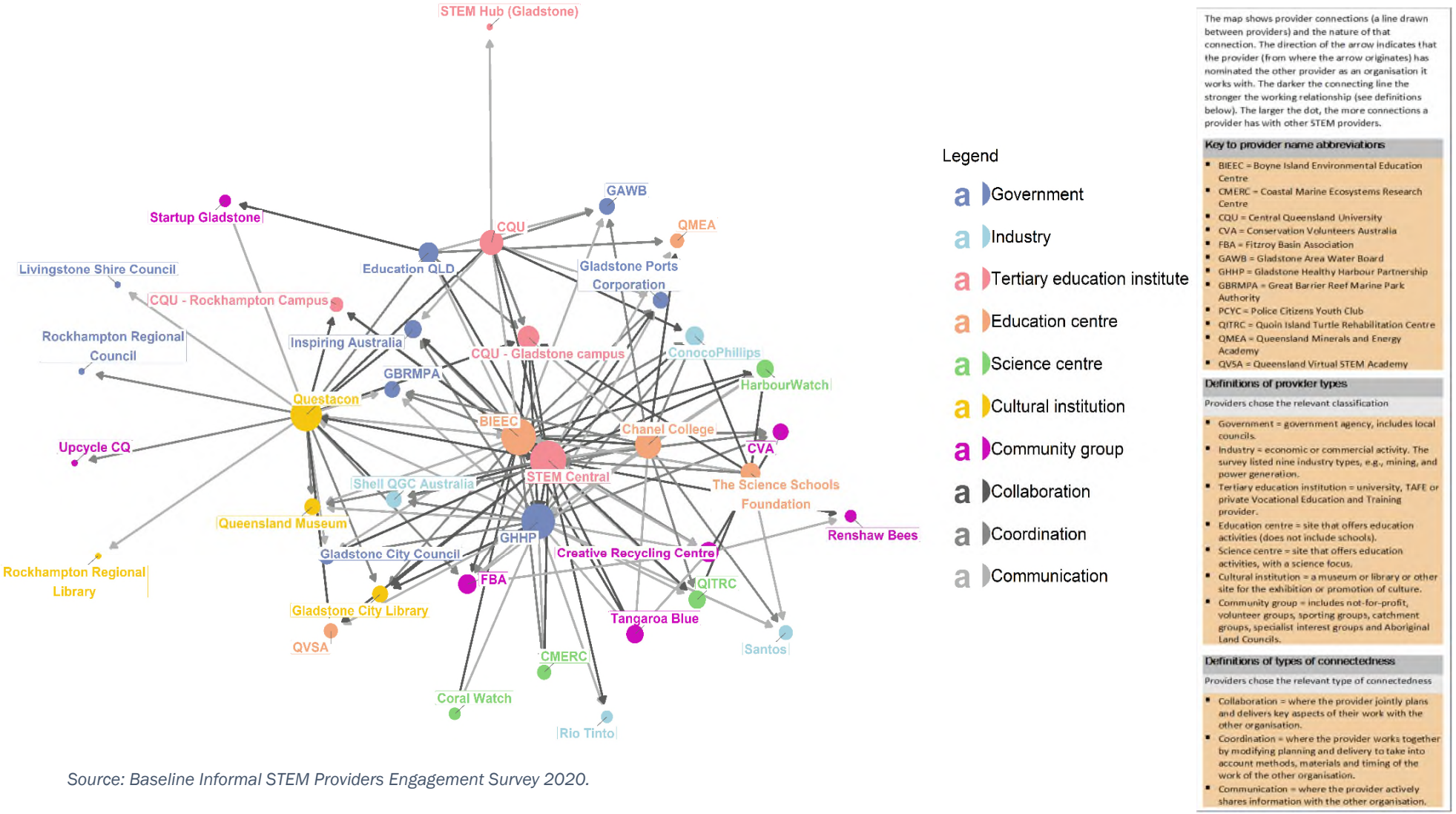
The 2019 Teacher Expo hosted by CQU's STEM Central successfully connected schools with 18 local informal providers.

Gladstone had a highly connected learning ecosystem. Tertiary institutions and education centres were acting as central nodes with the most connections to other providers. Interviews confirmed that these organisations commonly led joint planning and coordination across the network.

The Rockhampton ecosystem map confirmed the qualitative evidence that providers tended to be less well-connected to each other than was the case in Gladstone. Far fewer providers in this study were from Rockhampton. It is difficult to know if they represented the views of the whole STEM learning ecosystem.

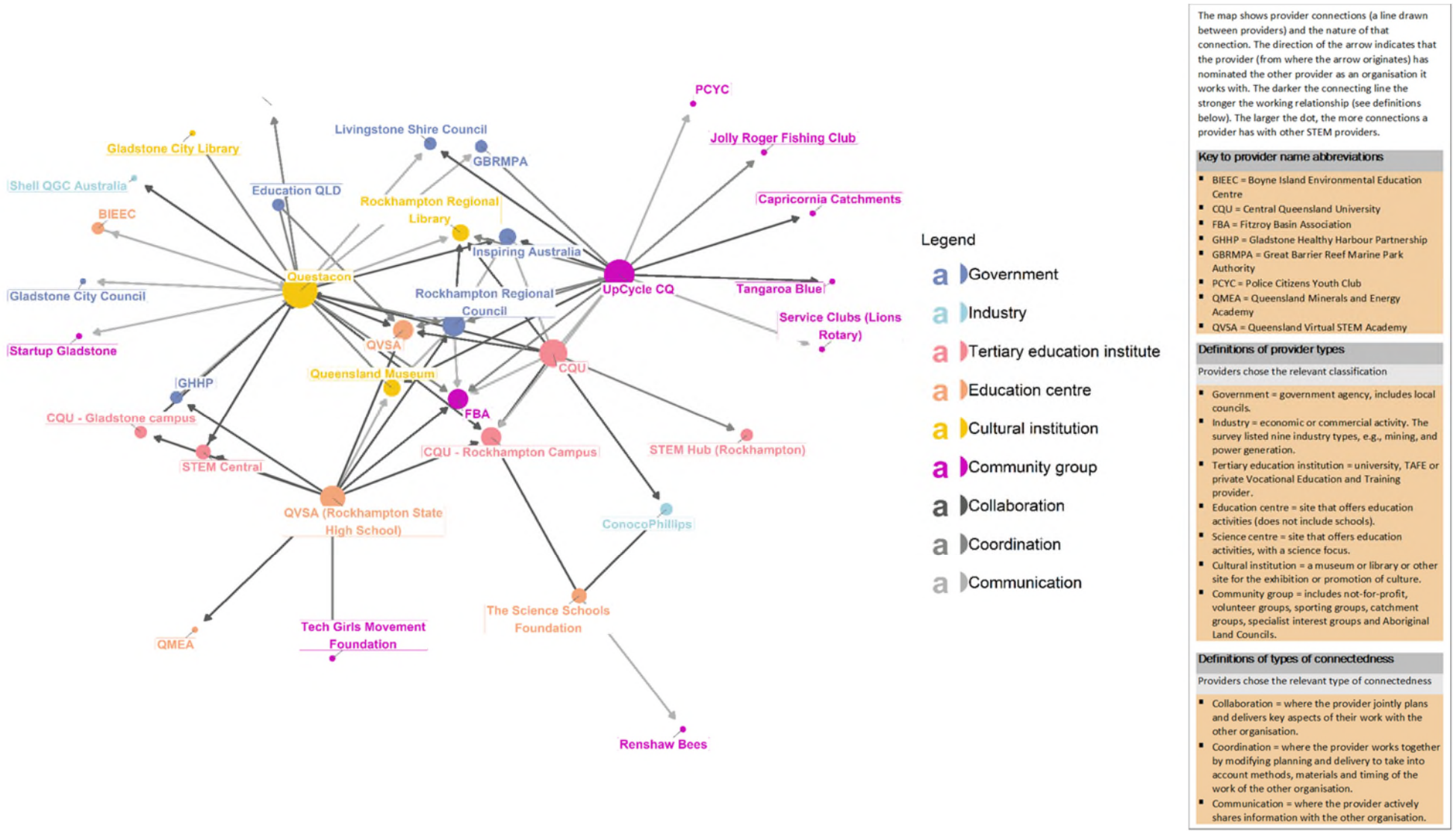
Both ecosystem maps identified some main organisations that were connectors with a presence or relationships within both Gladstone and Rockhampton ecosystems providing a strong foundation for greater coordination and collaboration across the regions.

FIGURE 14 MAP OF GLADSTONE STEM LEARNING ECOSYSTEM CONNECTEDNESS LEVELS



Source: Baseline Informal STEM Providers Engagement Survey 2020.

FIGURE 15 MAP OF ROCKHAMPTON STEM LEARNING ECOSYSTEM CONNECTEDNESS LEVELS



The map shows provider connections (a line drawn between providers) and the nature of that connection. The direction of the arrow indicates that the provider (from where the arrow originates) has nominated the other provider as an organisation it works with. The darker the connecting line the stronger the working relationship (see definitions below). The larger the dot, the more connections a provider has with other STEM providers.

Key to provider name abbreviations

- BIEEC = Boyne Island Environmental Education Centre
- CQU = Central Queensland University
- FBA = Fitzroy Basin Association
- GHHP = Gladstone Healthy Harbour Partnership
- GBRMPA = Great Barrier Reef Marine Park Authority
- PCYC = Police Citizens Youth Club
- QMEA = Queensland Minerals and Energy Academy
- QVSA = Queensland Virtual STEM Academy

Definitions of provider types

Providers chose the relevant classification

- Government = government agency, includes local councils.
- Industry = economic or commercial activity. The survey listed nine industry types, e.g., mining, and power generation.
- Tertiary education institution = university, TAFE or private Vocational Education and Training provider.
- Education centre = site that offers education activities (does not include schools).
- Science centre = site that offers education activities, with a science focus.
- Cultural institution = a museum or library or other site for the exhibition or promotion of culture.
- Community group = includes not-for-profit, volunteer groups, sporting groups, catchment groups, specialist interest groups and Aboriginal Land Councils.

Definitions of types of connectedness

Providers chose the relevant type of connectedness

- Collaboration = where the provider jointly plans and delivers key aspects of their work with the other organisation.
- Coordination = where the provider works together by modifying planning and delivery to take into account methods, materials and timing of the work of the other organisation.
- Communication = where the provider actively shares information with the other organisation.

Source: Baseline Informal STEM Providers Engagement Survey 2020.

Formal networks

Many informal providers were participating in the local STEM networks, and accessing local STEM hubs. Some providers were also active members of national or state STEM networks. Schools were represented in some informal STEM networks.

A Queensland government grant funded the Gladstone schools STEM cluster to facilitate cross-school engagement and practice support.

Local STEM networks were supported by funding grants. Stakeholders pointed to the benefits of a well-resourced coordination function and active leadership for a network to flourish. (See **Appendix 1** for more information on STEM networks)

Informal provider and school attitudes on collaboration

Of the 12 informal STEM providers responding, half (50%) agreed that '*it is easy to work together*' while 59% felt that '*it is easy to work with schools*'. Two-thirds (67% felt there were '*high levels of trust between providers*' (**FIGURE 16**). Half of providers (50%) believed '*local networks can demonstrate outcomes of collective work';* another indicator of a collective mindset.

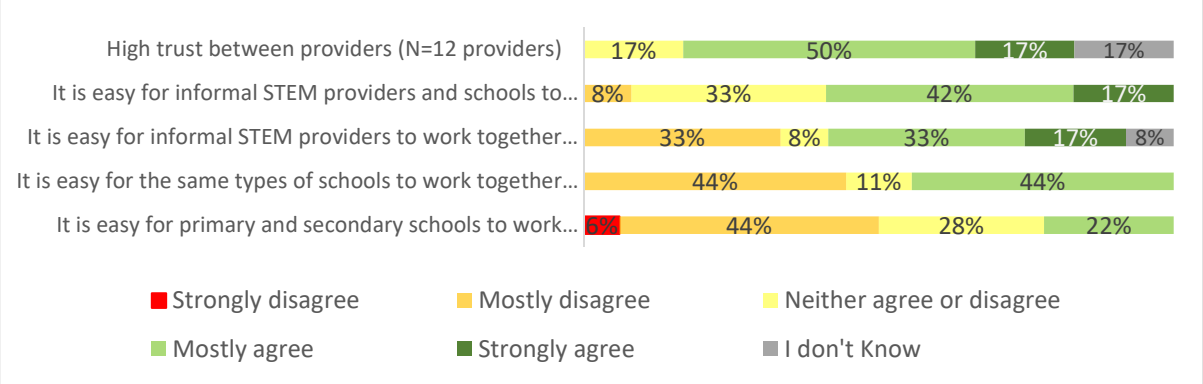
Interviewees pointed to the competition for resources amongst providers as a challenge for collaboration and growing the provider pool.

From our small sample of schools (N=18), schools were less positive about their capacity to work with each other Less than half (44%) found it easy for schools to work together and only 22% agreed when they were schools of different types (i.e. primary and secondary schools).

> *"Getting everyone connected is still a challenge. There's many groups and networks and these organisations are trying to work together, even if they haven't got there. But I think relationships are very strong here. Mainly built on trust over time."*
>
> *[Informal STEM learning provider]*

An identified challenge of working together for providers and schools was connecting with the appropriate educators in a school to offer or coordinate STEM activities, particularly in secondary schools. The Department of Education had a future plan to allocate STEM coordinators at schools who could be a designated contact for informal providers.

FIGURE 16 STEM PROVIDER AND SCHOOL PERSPECTIVES ON WORKING TOGETHER



Sources: Baseline Schools STEM Engagement Survey 2020 and Informal STEM Providers Engagement Survey 2020.

Learning Pathways

DESIGNED PATHWAYS ENABLE YOUNG PEOPLE TO BECOME ENGAGED, KNOWLEDGEABLE AND SKILLED IN STEM AS THEY PROGRESS THROUGH CHILDHOOD INTO ADOLESCENCE AND EARLY ADULTHOOD

A focus on learning pathways reflects a shared responsibility to broker the knowledge, tools support and connections that a young person needs to navigate the STEM learning ecosystem and potentially progress into a STEM career [29]

KEY BASELINE MEASURES

- STEM pathways programs/ initiatives
- Connections between school, out-of-school and post-school STEM

KEY FINDINGS

STEM learning pathways indicated an 'interactive' ecosystem.

The study identified several initiatives to strengthen STEM pathways offered through schools, tertiary institutions and industry.

Providers identified challenges maintaining connections between schools and out-of-school STEM opportunities.

STRENGTHS

Tertiary institutions offered roadshows, expos, career days, academic programs, outreach and other informal STEM learning pathways opportunities.

Several major government and industry partnerships offered career support and programs to strengthen learner pathways.

In our small sample, secondary schools (N=6) offered STEM pathway programs, for example apprenticeships or traineeships.

IDENTIFIED GAPS OR CHALLENGES

Interviewed stakeholders discussed the challenges of maintaining learning pathways between school and informal STEM learning opportunities. Challenges included connecting with schools, targeting programs to school needs and ensuring schools had a good understanding of the available STEM opportunities.

[29] Tan, E., Calabrese Barton, A., Kang, H. and O'Neill, T. 2013 "Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science", *Journal of Research in Science Teaching*, 50 (**10**): 1143-1179

Learning Pathways

STEM pathways programs/ initiatives

A list of known STEM pathway programs offered in Australian secondary schools was listed in the survey. A number of surveyed schools offered STEM pathway programs, Most commonly "school-based apprenticeships or traineeships in STEM-related industries" and "vocational education and training pathways" (**TABLE 4**).

Education Queensland and Industry Partnership (EQUIP) acts as a central management body for the various vocational education training programs across Gladstone State secondary schools.

Beyond formal programs, some schools have introduced their own initiatives. However, improving pathways to STEM careers was not an identified focus for most schools (one of 18 schools identified it as a focus area).

'We have introduced a new STEM elective focused on inspiring students towards STEM career pathways. The first elective planned for 2021 focuses on use of drones in an industry context for the Year 8 cohort. The school intends to add electives based around varying topic areas for each year group.'

[Gladstone teacher]

TABLE 4 STEM PATHWAY PROGRAMS IN SECONDARY SCHOOLS

STEM pathway opportunities	Offered	Not	Unsure	Total
School apprenticeships or traineeships in STEM industries	5	0	1	6
Vocational education and training programs	5	0	1	6
Trade Training Centres Program[30]	4	1	1	6
Pathways in Technology (P-TECH) Program[31]	1	1	4	6
Mentoring programs for STEM students	1	4	1	6
CareerTrackers Indigenous Internship Program[32]	1	1	4	6

Source: Baseline Qld Schools STEM Engagement Survey 2020.

[30] Trade Training Programs in Schools is a national program to help students successfully move to further education, training or work.
[31] Australian Government pilot study at 13 sites where an innovative model of education-industry collaboration provides students studying for their Senior Secondary Certificate with an industry supported pathway to a STEM related diploma, advanced diploma or associate degree
[32] CareerTrackers is a national program that creates paid internship opportunities for Indigenous students.

Both CQU and UQ have STEM outreach programs for secondary students. CQU hosts career days and STEM expos/roadshows. CQU Rockhampton and Gladstone campuses both offer academic programs and vocational education for STEM-related careers including:

- Centre for Railway Engineering; and the Centre for Intelligent Systems (Rockhampton)
- Coastal Marine Ecosystems Research Centre (Rockhampton)
- Environmental Health Centre (Rockhampton)
- School of Manufacturing (planned) (Gladstone)
- School of Mining (planned) (Rockhampton).
- STEM vocational training run by Site Skills Training.

Many companies invest in traineeships linked to vocational education and training pathways, apprenticeships and other career pathway programs.

The CQU school outreach team, CQUni Connect, had offered outreach to more than 50 secondary schools in lower socio-economic areas to work with students interested in STEM careers on university pathways/career opportunities.

The outreach team has become a conduit between academics eager to make connections with schools around STEM.

The PREQIP Indigenous Program is a career support program for students to investigate and be counselled around potential career opportunities in the region.

Connections between school, out-of-school and post-school STEM programs

Most surveyed informal STEM providers were focused on 'improving pathways to STEM careers' for students (70%, N=12).

Stakeholders commented on the investment from the local resource industries in Gladstone to seed collaborations between STEM providers, schools, and industry. The investment had allowed schools to engage students in STEM enrichment programs in and out of school.

Many providers had formed partnerships with schools and other providers, particularly industry-funded centres (for example, STEM Central and Queensland Minerals and Energy Academy), to strengthen learner pathways.

Informal STEM providers' perceptions were that STEM learning pathways were connected in the regions. Providers believed that local schools, industry, and universities were engaged and committed to creating STEM learning pathways for students.

Still, few providers reported success in addressing barriers to STEM opportunities in the region. Interviewed stakeholders mentioned the challenges in creating learning pathways between formal and informal STEM education opportunities including:

- Marketing – schools didn't always have a good understanding of the range of STEM learning opportunities on offer.
- Linking – appropriately targeting programs and resources to meet schools' needs, i.e. explicitly linking to the curriculum and subject planning.
- Sustaining – offering opportunities with sufficient regularity when teachers are time poor and there are limited resources.

Conclusion

This study aimed to conduct a rapid assessment of the STEM learning ecosystem in the Central Queensland regions of Gladstone and Rockhampton and trialled a framework for measuring a STEM learning ecosystem.

The study focused on the collective role of organisations in equipping young people for the future, informal STEM providers and their interaction with formal education. We identified 5 outcome dimensions and associated measures for optimising STEM learning in a robust STEM learning ecosystem. We then developed a rubric to assess the robustness and resilience of the learning ecosystem using a scale of *individual, interactive* and *interconnected*.

What we found

Overall, the study findings indicated an *interactive* STEM learning ecosystem in Gladstone/Rockhampton. The dimensions of *shared vision, diversity and density of STEM rich-experiences* and *learning pathways* indicated an *interactive* ecosystem. The dimensions of *capacity* and *relationships* indicated an *interconnected* ecosystem.

Differences in the STEM learning ecosystems between Gladstone and Rockhampton were difficult to distinguish because of the small sample and overlap in the organisations operating in both regions. The Gladstone STEM learning ecosystem appeared stronger and more interconnected because of the number and diversity of identified providers, leadership, and mechanisms for collaboration and coordination.

A high density and diversity of providers and STEM experiences were available for schools and communities. A range of formal initiatives to strengthen STEM pathways were found. However, findings suggested a missing strategic connection between informal providers and schools that could support better targeting and uptake of informal learning opportunities.

What next

This snapshot of the STEM learning ecosystem in Gladstone/Rockhampton region represented a typical year pre-pandemic, and provided a benchmark for understanding, and tracking changes in, the STEM learning environment. While the Study had limitations, participating informal providers, schools and other stakeholders gave valuable data and insights.

There were several emerging opportunities from this Study.

- Engaging with regional stakeholders in the spirit of sharing and collaboration
  - Confirming indicative findings and exploring the value and potential use of the baseline for national and regional stakeholders
  - Exploring whether stakeholders consider a STEM learning ecosystem approach useful
  - Discussing the main opportunities and challenges to strengthen the STEM learning ecosystem
  - Facilitating connections and learning between regions
- Shaping Questacon's practice and focus
  - Defining outcomes and activities for the next 6 or 12 months
  - Considering how our own practice is contributing to the 5 learning ecosystem dimensions
  - Placing a greater emphasis on understanding specific local needs and interests

- Working with state and regional authorities and partners
- Investing in tailored opportunities with multiple touchpoints to deepen engagement and outcomes
- Sharing practice with other STEM providers

❖ Progressing thinking about learning ecosystem concepts and principles to strengthen practice and outcomes

- Testing if applying place-based, collaborative practice and a focus on the ecosystem leads to greater impact
- Promoting the need for further research into STEM learning ecosystem theory and application in Australian settings.

APPENDIX 1 STEM PROVIDERS AND NETWORKS IN GLADSTONE AND ROCKHAMPTON

Provider name	Type	Presence
Australian Resources and Energy Group AMMA (Bright Future)	Industry	National
Boyne Island Environmental Education Centre (includes Harbour Watch)	Education centre	Gladstone
Brisbane Science Museum	Cultural Institution	State
Capricornia Catchments	Community group	Rockhampton
Capricorn Caves	Community group	Rockhampton
Central Queensland University – Gladstone, including - STEM Central - Coastal Marine Ecosystems Research Centre	Tertiary institution	Gladstone
Central Queensland University – Rockhampton, including: - Advanced Technology and Innovation Centre (ATIC)	Tertiary institution	Rockhampton
CEO Robots Challenge. Robotics Education and Competition Foundation	Education centre	National
ConocoPhillips (Australia Pacific LNG)	Industry	National
Conservation Volunteers Australia (CVA)	Community group	National
CoralWatch	Science centre	State
Creative Recycling Centre	Community group	Gladstone
Dr Damien Kee	Education centre	National
Fitzroy Basin Association	Community group	Gladstone Rockhampton
Gladstone Area Water Board (GAWB)	Government	Gladstone
Gladstone City Library	Government	Gladstone
Gladstone Healthy Harbour Partnership	Government	Gladstone
Gladstone Ports Corporation	Government	Gladstone
Great Barrier Reef Marine Park Authority	Government	Rockhampton
Inspiring Australia	Government	National
IMPACT Centre	Government	State
Jolly Rogers Fishing Club	Community group	Rockhampton
Livingstone Shire Council	Government	Rockhampton
Minds at Work	Education centre	National
North Keppel Island Environmental Education Centre	Education centre	State
Police Citizens Youth Club	Community group	National
Questacon	Cultural institution	National
Queensland Minerals and Energy Academy	Education centre	State

Provider name	Type	Presence
Queensland Museum	Cultural Institution	State
Queensland Virtual STEM Academy (QVSA)	Education centre	State
Quoin Island Turtle Rehabilitation Centre	Science centre	Gladstone
Redshaw Native Bees	Community group	Rockhampton
Rockhampton Regional Council	Government	Rockhampton
Rockhampton Regional Library	Government	Rockhampton
Rio Tinto	Industry	National
Santos	Industry	National
Shell QGC Australia	Industry	National
Startup Gladstone	Community group	Gladstone
Site Skills Training	Tertiary institution	Gladstone Rockhampton
Tangaroa Blue	Community group	National
The Science Schools Foundation	Education centre	National
Service clubs (Lions Club Australia; Rotary)	Community group	National
Tech Girls Movement Foundation	Education centre	National
UpCycle CQ	Community group	Rockhampton
University of Queensland	Tertiary institution	State

Notes: This list is not complete. The list is identified via the baseline research. Sources: Baseline Informal STEM Providers Engagement Survey 2020. Names of STEM providers come from (a) the names of organisations of which respondents of the Baseline Informal STEM Providers Engagement Survey 2020 represented, (b) STEM providers listed as options in the Baseline Informal STEM Providers Engagement Survey 2020, and (c) STEM providers nominated by respondents in the Baseline Informal STEM Providers Engagement Survey 2020, (d) Providers listed as offering incursions or excursions in the Baseline Schools STEM Engagement Survey 2020 and, (e) Providers mentioned in interviews.

STEM hubs

Two informal STEM 'hubs' were identified, STEM Central (Gladstone) and the Advanced Technology and Innovation Centre (Rockhampton). These hubs are managed by CQU; both hubs benefit from industry and government funding. Providers and schools use the spaces in these hubs to offer STEM engagement activities.

STEM networks

Three formal active STEM networks were identified with a presence in one or both of the regions in 2019. Two of these networks had a presence in Gladstone—Inspiring Australia's Central Queensland STEM Hub (Gladstone), and the Gladstone schools STEM cluster. There was one STEM network identified in Rockhampton, the Rockhampton Resource STEM Network.

Inspiring Australia's Central Queensland STEM Hub (Gladstone)

This local STEM network received grant monies from Inspiring Australia, a national initiative, to offer science engagement activities. Inspiring Australia is planning to offer more opportunities for members, more regular meetings, and online monthly training sessions for those running STEM events.

Network members, estimated by stakeholders to be 15 to 20 regular attendees, encompassed a broad range of mainly Gladstone-based providers, including multiple local schools. The network has formal governance arrangements in place, including a charter, vision statement, and development of annual plans, and members meet 4 times a year. Members come together to organise and deliver agreed STEM engagement activities, for example, a teacher expo in 2019, and for Science Week. In 2020, the main driver of network activities is the network coordinator, who is widely recognised by other providers as having a connector role in the STEM learning ecosystem, bringing together informal STEM providers, industry representatives and schools.

Rockhampton Resource STEM Network

The Rockhampton Resource STEM Network was coordinated by a local STEM community organisation and does not receive any government funding. The network was relatively new with some membership from the original Inspiring Australia Rockhampton Hub, which ceased activity in 2019, reportedly due to difficulties finding an organisation to take on the coordination role and a lack of a structured planning process. Members of the Rockhampton Resource STEM commented that the lack of resources for coordinating the network and to support joint activities, inhibit the network's activities.

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