Australian Government

Questacon
The National Science and Technology Centre

The STEM Learning Ecosystem: A 2019 Snapshot

Northern Territory

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.

Contact

Enquiries should be addressed to:

Questacon
Tel: 02 270 2800
Email: Evaluation@questacon.edu.au
Website: www.questacon.edu.au

Disclaimer

www.questacon.edu.au

Contents

Figures and Tables

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 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 our activities with a focus on STEM leadership, collaboration, connections and capacity-building to achieve an enduring impact.

Language Usage

For general use, Questacon prefers the phrase 'First Nations' where we might previously have used terms such as Indigenous, Aboriginal or Torres Strait Islander. However, there are certain times when using 'Indigenous', 'Aboriginal' or 'Torres Strait Islander' is still appropriate. This includes when the word is part of the proper name of a program, organisation or job title, such as Indigenous Engagement Officer or Aboriginal Land Council. It is also appropriate to use well-established concepts which contain one or more of these words, like 'Indigenous STEM', 'Indigenous-led' and 'Indigenous engagement'. These terms are also appropriate to use when quoting a person who self-describes or self-associates with them[5].

[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)
[5] Adapted from *Questacon's Indigenous Engagement Strategy 2022-2026*, accessed 13/09/2022

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 the Northern Territory (NT) and forging relationships with other STEM providers.

We commissioned this study to create a snapshot of the STEM learning ecosystem in the NT. The study was also conducted in 2 other focus regions: Tasmania and Central Queensland (Gladstone and Rockhampton). 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 the NT, 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 THE NT

Data source	Areas of inquiry	Data (Response rate)
Informal STEM providers survey	STEM vision, activities, and connections	19 (Unknown)
School survey	STEM capacity, activities and connections	18 (32%,N=57 Darwin/Palmerston schools)
Stakeholder interviews	Regional STEM priorities, strengths and challenges	11 (85%, N=13 selected interviewees)

Questacon's framework for measuring the STEM learning ecosystem

Questacon drew on mature ecosystem models[6] and research[7] 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[8,9] 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

[6] https://stemecosystems.org/

[7] 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

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

[9] 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

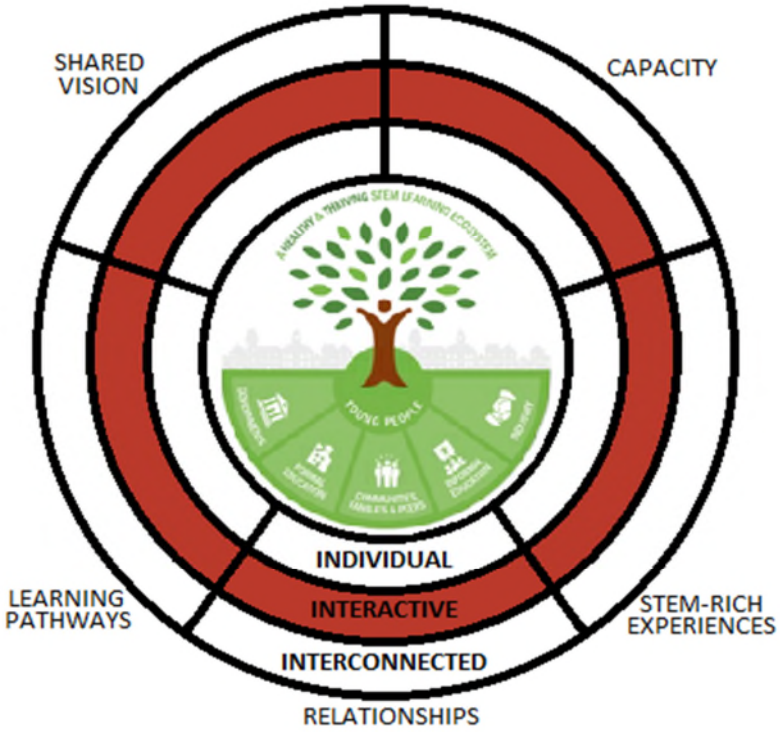
Overall, the study findings indicated an 'interactive' STEM learning ecosystem across all 5 dimensions of *shared vision*, *capacity and resources, diversity and density of STEM-rich experiences*, *relationships* and *learning pathways*.

The Study found a diversity of providers and STEM experiences for schools and communities and a range of formal initiatives to strengthen STEM pathways. Providers perceived that formal and informal STEM learning pathways could be more visible and strengthened to improve uptake of learning opportunities, particularly in remote settings. While the sample of schools was small and Darwin-centric, survey and interview data indicated opportunities to strengthen school and educator STEM capabilities, practices and resources.

Providers had mixed views on the presence of a shared vision for STEM and wide interest in the idea of a shared vision. Providers had awareness of other organisations and shared information. There was appetite for greater coordination and collaboration across informal providers and schools to realise a shared vision and improve connectivity across the learning ecosystem.

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 THE NT



SHARED VISION

- Mixed views on the existence of a shared vision for STEM.
- Interest in the idea of having a strategic framework for STEM through which informal providers could better align their activities with schools.
- Significant overlap in strategic areas of focus.

CAPACITY AND RESOURCES

- 58 diverse STEM providers identified.
- Local providers had a deep understanding of local knowledge, contexts, culture, and geography.
- Our small sample of schools (N=18), rated their STEM capacity low.

DIVERSITY AND DENSITY OF STEM-RICH EXPERIENCES

- In and out of school experiences offered across all age cohorts in a range of settings.
- Early childhood appeared less catered for.
- Reach was not able to be ascertained; but based on our sample, less than half of schools (41%, N=17) received a STEM incursion or excursion in a typical year.

LEARNING PATHWAYS

- STEM pathways programs and initiatives offered through school, the university, industry and informal STEM providers.
- Pathways could be better connected and more visible, particularly in remote areas.

RELATIONSHIPS

- Most informal STEM providers were ‘aware’ of each other but fewer had deeper connections.
- Connected providers were engaging at the level of communication, that is sharing information.
- Strong appetite to increase communication, coordination and collaboration.

What next

This snapshot of the STEM learning ecosystem in the NT 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 the Northern Territory (NT) 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 NT, 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.[10]

According to the STEM Learning Ecosystems Community of Practice[11], 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

[10] 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)

[11] 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.

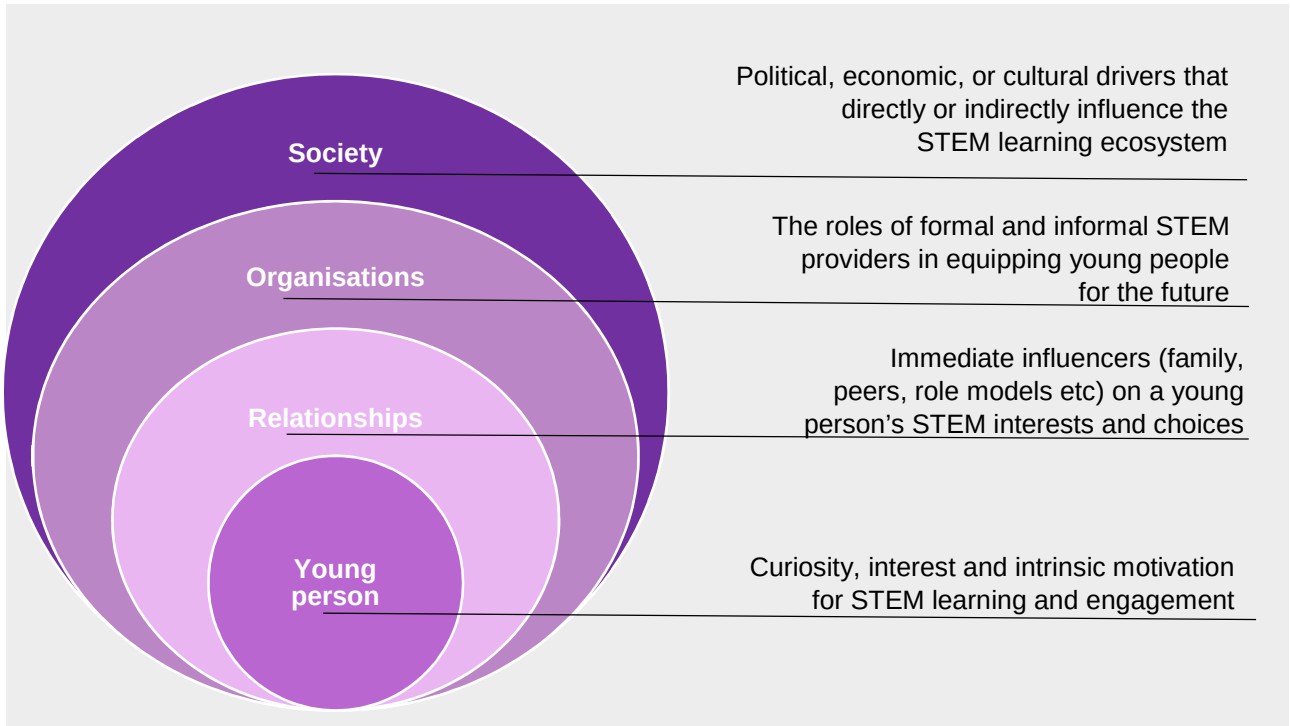
This study was commissioned to inform Questacon's understanding of STEM learning in the NT and 2 other focus regions; Tasmania and Central Queensland. It aimed to:

- 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[12], 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**).[13]

FIGURE 3 APPLYING AN ECOLOGICAL MODEL TO A STEM LEARNING ECOSYSTEM[14]



[12] Bronfenbrenner, Urie. 1979 *The Ecology of Human Development*. Harvard University Press
[13] Hannon, V. *et al*. 2019 *Local learning ecosystems: emerging models*, Innovation Unit, WISE
[14] 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 the NT 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[15] and research[16] 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[17,18] we then developed a rubric to assess the resilience of STEM providers in the STEM learning ecosystem using the following 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 4**). 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.

[15] https://stemecosystems.org/
[16] 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
[17] Innovation Ecosystem Maturity. I do not believe in comparing different… | by Monika Rozalska-Lilo | CREATORS | Medium
[18] 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 2 MEASURING THE ROLE OF STEM PROVIDERS IN STEM LEARNING ECOSYSTEMS[19]

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

[19] 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[20] and a document review. Data sources are outlined in **TABLE 3**.

TABLE 3 STUDY DATA COLLECTION

Evidence source	Data collected	Response rate
Survey of informal STEM providers	19	Unknown[21]
Survey of schools (Darwin/Palmerston)	16 government schools 2 catholic schools	32% (N=57 Darwin/Palmerston schools)
Stakeholder interviews	11 interviews completed	85% (N=13 selected interviewees)
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 who received the survey, was used to broaden the reach of the survey and hence increase the total number of completed surveys. It is not possible to know how many providers received an email survey invitation and a response rate cannot be calculated. It is also unclear how representative our sample was of all provider types and NT regions.

Schools survey

An online survey link was sent by the Department of Education to 128 members of the Department's STEM Network across Darwin/Palmerston schools (N=57). Overall, the response rate from schools was low and it's not possible to know whether schools may have submitted more than one response.

[20] 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

[21] Snowballing method was used to distribute the survey so the sample size is unknown.

Key Findings

In the NT, 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 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 5ASSESSMENT OF THE STEM LEARNING ECOSYSTEM DIMENSIONS AND RESILIENCE

SHARED VISION

- Mixed views on the existence of a shared vision for STEM.
- Interest in the idea of having a strategic framework for STEM through which informal providers could better align their activities with schools.
- Significant overlap in strategic areas of focus.

CAPACITY AND RESOURCES

- 58 diverse STEM providers identified.
- Local providers had a deep understanding of local knowledge, contexts, culture, and geography.
- Our small sample of schools (N=18), rated their STEM capacity low.

DIVERSITY AND DENSITY OF STEM-RICH EXPERIENCES

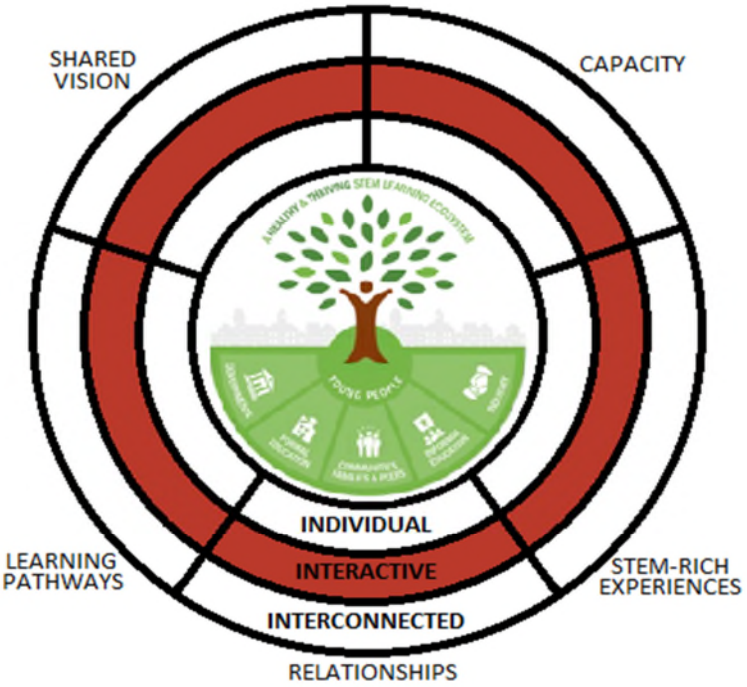
- In and out of school experiences offered across all age cohorts in a range of settings.
- Early childhood appeared less catered for.
- Reach was not able to be ascertained; but based on our sample, less than half of schools (41%, N=17) received a STEM incursion or excursion in a typical year.

LEARNING PATHWAYS

- STEM pathways programs and initiatives offered through school, the university, industry and informal STEM providers.
- Pathways could be better connected and more visible, particularly in remote areas.

RELATIONSHIPS

- Most informal STEM providers were ‘aware’ of each other but fewer had deeper connections.
- Connected providers were engaging at the level of communication, that is, sharing information.
- Strong appetite to increase communication, coordination and collaboration.



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[22]

KEY BASELINE MEASURES

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

KEY FINDINGS

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

Informal STEM providers and schools held mixed views about a shared vision for STEM in the NT.

Many providers identified the potential benefits of having a visible strategic framework for STEM through which informal providers could better align their priorities and activities with schools.

STRENGTHS

Informal providers and schools both ranked '*growing STEM engagement*' and the '*diversity of STEM learners*' as the top 2 areas of focus, suggesting overlapping strategic priorities, though few reported success against these areas.

The NT Department of Education's *STEM in the Territory Strategy 2018-2022* set out priorities for schools and educators accompanied by *STEM School Matrices*, a tool for schools to track their progress in STEM education programs.

IDENTIFIED GAPS OR CHALLENGES

From our small sample of 17 providers, less than half of informal STEM providers (41%) believed there was a shared vision for STEM in the region. Of 13 schools responding to this survey question, 31% thought there was a shared vision for STEM.

Both informal STEM providers and schools reported limited success in achieving strategic areas of focus.

Providers reported lacking the resources and time to focus on strategic issues affecting the sector.

[22] 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

Less than half of informal STEM providers (41%, N=17) and one-third of schools (31%, N=13) believed there was a shared vision for STEM in the region. Notably, 29% of informal providers reported that they didn't know.

Some providers commented that they lacked a clear vision for STEM within their own organisations. STEM priorities were described by some stakeholders as being short-term and reactive rather than proactive and addressing longer term issues.

Providers commonly expressed that the region might benefit from a visible strategic framework that set out priorities through which informal and formal providers could align their activities. Providers proposed suggestions about creating any future strategic frameworks for STEM education (see Box).

Provider suggestions about creating a cross-sector strategic framework for STEM:

- *Reflect the local context (environment, community/cultural assets, learning needs)*
- *Consult with academic and industry researchers*
- *Co-design with STEM education and science communication experts, such that priorities are easily understood and are able to be implemented,*
- *Create an openly accessible register of informal STEM providers, and STEM networks and hubs*
- *Articulate long-term priorities and a clear governance framework, including who will champion them*

Documented policy/ strategy

The NT Department of Education's *STEM in the Territory Strategy 2018-2022* sets out priorities for schools and educators accompanied by *STEM School Matrices*, a tool for schools to track their progress in STEM education programs.

More broadly, government investment is also evident in grants aimed at building STEM and education quality

- Building Better Schools program, $56.4 million between 2017 and 2021 supports generational change and ensure all Territory children have access to quality infrastructure to support quality learning
- $39 million between 2017 and 2021 to improve infrastructure on the Bullocky Point Education Precinct in Darwin and includes the STEAM Centre at Darwin Secondary school and the Multi-Purpose Hall at Darwin Middle School
- Taminmin College STEAM Centre, $12.7 million. The Centre includes 6 classrooms and labs, with the capacity to cater for 1,500 students.

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.

Informal providers and schools ranked '*Growing STEM engagement*' and '*Diversity of STEM learners*' as top focus areas (**FIGURE 6** and **FIGURE 7**)

Focus areas relating to confidence and capacity of STEM providers and quantity and diversity of STEM providers did not resonate with the responding providers or schools and few reported success.

'*Improving STEM career pathways*' was the lowest ranking focus area for schools.

For areas that were a major focus, both informal STEM providers and schools reported limited success. The focus areas where informal providers reported experiencing most success were:

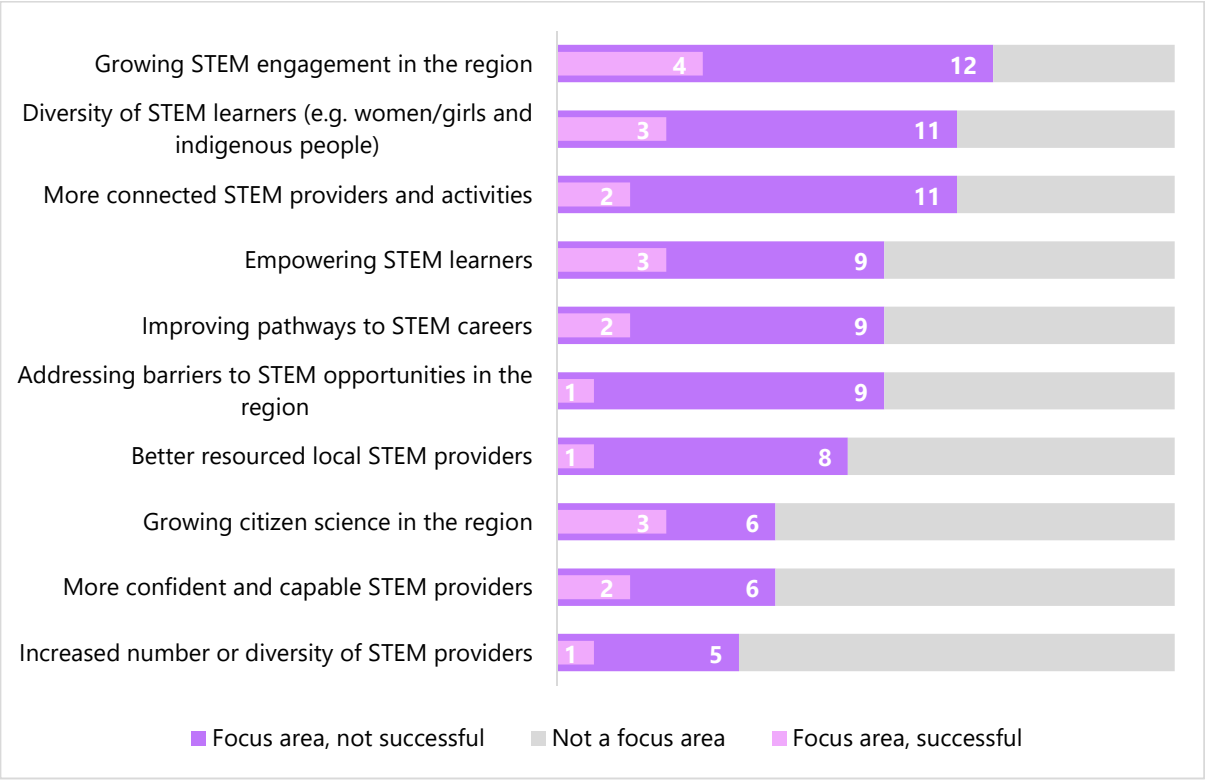
- *'Growing STEM engagement in the region'*
- *'Empowering/diversity of STEM learners'*
- *'Growing citizen science in the region'* (for the small number focused on this area).

The focus areas where informal providers reported experiencing the least success were:

- *'Addressing barriers to STEM opportunities in the region'*
- *'Better resourced local STEM providers'*
- *'More connected STEM providers and activities'.*

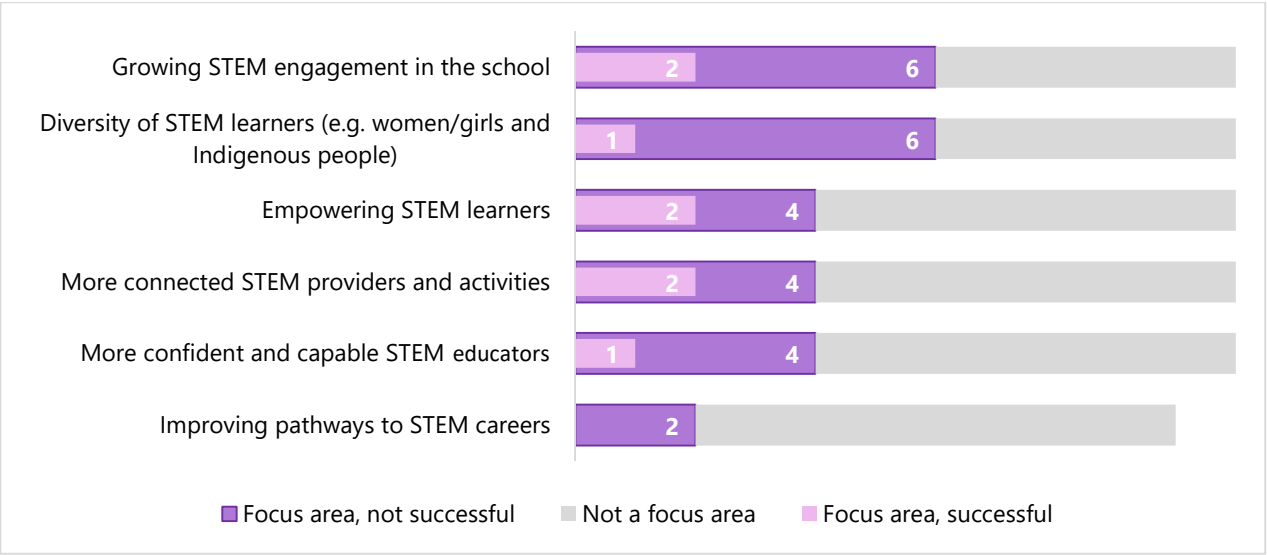
Given the survey offered a pre-defined list, providers' own strategic priorities were not elicited from the survey and may not be adequately reflected.

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



Notes: N=17 Missing data=2 Source: Baseline NT Informal STEM Providers Engagement Survey 2020

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



Notes: N=11. Missing data=7. Source: Baseline NT Schools STEM Engagement Survey 2020.

.

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 'interactive' ecosystem in the NT.

Fifty-eight diverse informal providers identified with a presence in the NT suggesting strong collective capacity for informal STEM engagement and education.

Our small sample of Darwin/Palmerston schools (N=18), schools rated their STEM capacity low.

STRENGTHS

A diversity of informal STEM providers identified across government, industry, education, cultural institutions and non-government organisations.

Local providers identified their unique ability to respond to community interests and needs because of in-depth understanding of local contexts, culture, and geography.

Many First Nations organisations were bringing knowledge and lived experience of First Nations perspectives on STEM and connections with Aboriginal and Torres Strait Islander communities.

IDENTIFIED GAPS OR CHALLENGES

Many informal providers mentioned a lack of resources to deliver programs across sparsely located communities with sufficient regularity to achieve sustained outcomes for young people.

Many informal providers observed that STEM was prioritised differently across schools and the uptake of STEM education programs was variable depending on the motivation of individual teachers.

Our sample (N=18) of schools rated the support for STEM in schools and teaching practices low. Further, 12% of surveyed schools perceived that there was high student demand for STEM. Noting the small sample size of schools, more data is needed to confirm these findings.

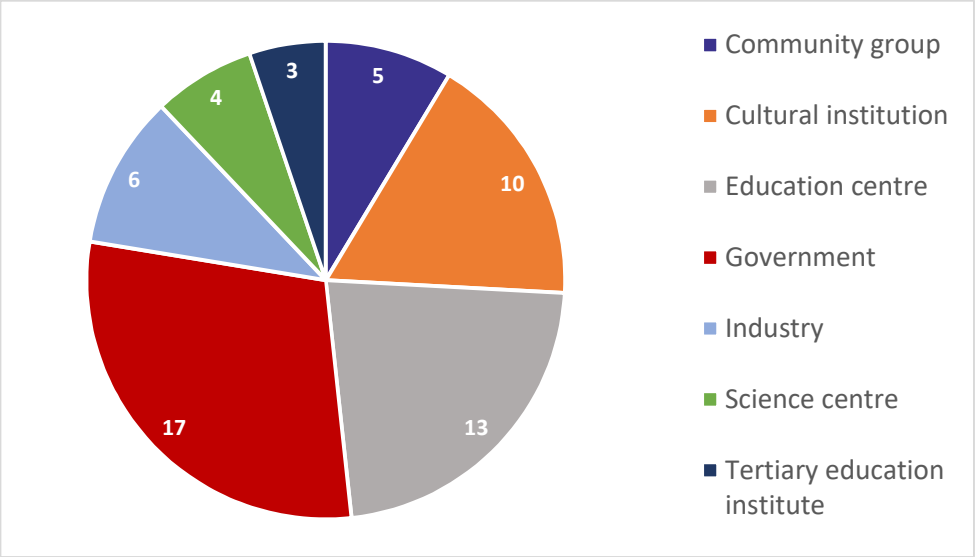
Capacity and Resources

Number and diversity of informal providers

The study identified 58 STEM providers offering informal STEM experiences in the NT; 36 of these were local to the NT and the rest national and interstate organisations (Refer to the list 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 Indigenous and non-Indigenous cultural institutions, environmental foundations/groups, community groups/organisations, and education and science centres. Most providers identified as cultural institutions, education centres, and government bodies (FIGURE 8).

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



Notes: N=58. Providers only counted once. 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.

Informal provider organisational strengths

A strength identified by local STEM providers was cultural competency. Several Indigenous and non-Indigenous STEM organisations mentioned bringing knowledge and lived experience of First Nations perspectives on STEM and connections with First Nations communities.

CSIRO's Inquiry for Indigenous Science Students program seeks to increase student engagement and achievement in science by providing teacher professional learning to embed Indigenous cultural knowledges through hands-on inquiry-based project

One local STEM provider remarked that the delivery of STEM education programs could be even better tailored to Aboriginal and Torres Strait Islander students' needs, for example, being delivered on Country, and being less rigid and structured. An Aboriginal identifying stakeholder reflected that Aboriginal and Torres Strait Islander people needed to be consulted in preparing STEM curricula so that cultural knowledge and pedagogies are incorporated.

Many providers commented that national STEM education programs do not always translate well in the NT if they do not consider the importance of culture, Country and seasons.

Providers also identified STEM promotion and program visibility as a strength of NT providers. In regional areas such as the NT it was easier to promote STEM activities and events, including using state-wide media. Providers commented that those providers with a positive reputation or brand, or an active digital presence were more successful in STEM activity promotion and engagement. Networks were also important to increase the visibility of STEM programs.

"Being in a small regional town, I would say it's probably easier for us to get mainstream coverage. By mainstream, I mean things like NT News, ABC Darwin, and things like that, because they're hungry for local content and we can provide that in spades."

[Informal STEM provider]

Providers reported that they often lacked the capacity to be proactive or strategic about STEM provision. As discussed, *(Shared Vision)*, surveyed STEM providers self-assessed their success as low for strategic objectives such as '*growing STEM engagement*', '*reaching a diversity of learners*', and '*better connecting providers and activities'*. Around half of the providers reported a focus on '*addressing barriers to STEM in the region*' and '*better resourcing providers*', with one provider reporting success in these areas.

Provider resources (people, time, money)

The NT is a remote region, both from other states/territories, and between NT communities. Providers observed that remote communities have fewer STEM teachers, offer fewer STEM subjects in schools, and have less access to informal STEM providers. Consequently, remote students have fewer opportunities to engage with STEM learning and associated skill building.

Providers felt that regular repeated engagement was necessary to impact school-aged students' educational outcomes, including study/career choices. Yet, they were often unable to engage schools regularly because of human resources and high administrative and travel costs associated with delivering activities in dispersed/remote communities.

The high rate of staff turnover in the NT was an ongoing challenge for developing and maintaining programs and relationships.

> *"People weren't staying more than two years. The documentation of the projects wasn't amazing as a result of that, and the network loss meant that you have to rebuild all those relationships all over again. That just makes everything slower to get moving … I've been in my role now for four years and I've definitely been here the longest."*
>
> [Informal STEM education provider]

STEM teaching support, practices and resources in schools

Overall, a small number of Darwin/Palmerston schools (N=18) responded to the survey. Schools rated their STEM capacity low, though the small sample size meant findings could not be generalised to all schools.

Less than half the schools (44%) agreed that they had access to high quality resources for STEM learning and 39% agreed that they had adequate support for STEM. Around one-quarter (23%) agreed that professional development within school improved STEM teacher capacity and 28% collaborated with other teachers around STEM (**FIGURE 9**).

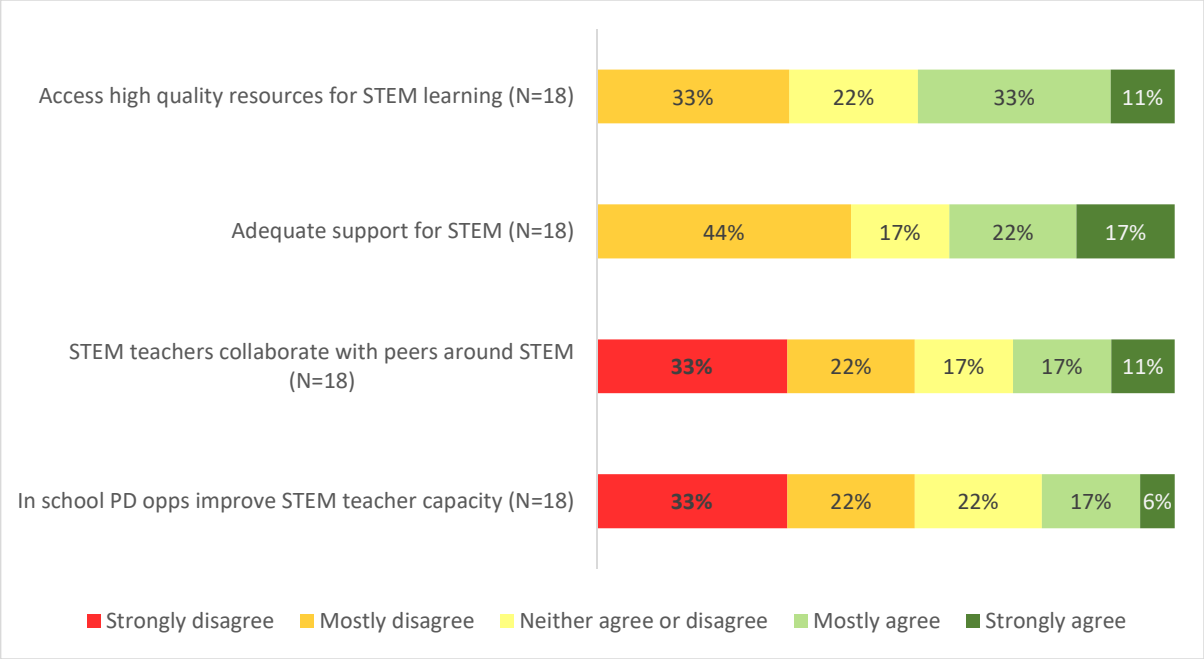
> *"[Partnerships] that work really well are working quite closely with us and getting direction from us around what schools need, but they also do approach schools directly. And they have something to offer."*
>
> [Formal Education Provider]

Providers reported that schools vary in the extent to which they prioritise the delivery of STEM, and not all schools include STEM as a focus in their strategic plan. One formal provider explained that the planned 'scoping sequence' can limit the uptake of new STEM education programs.

Many informal providers observed that the uptake of STEM education programs in schools was variable depending on the motivation of individual teachers. Twenty-four percent of schools reported that STEM incursions/excursions were important.

Interviewed education providers felt that STEM leaders in schools could be better assisted by articulating and formalising their roles as STEM champions, and by including regular follow-ups to support pedagogy, timetabling and lesson planning.

FIGURE 9 STEM RESOURCES AND SUPPORT IN SCHOOLS

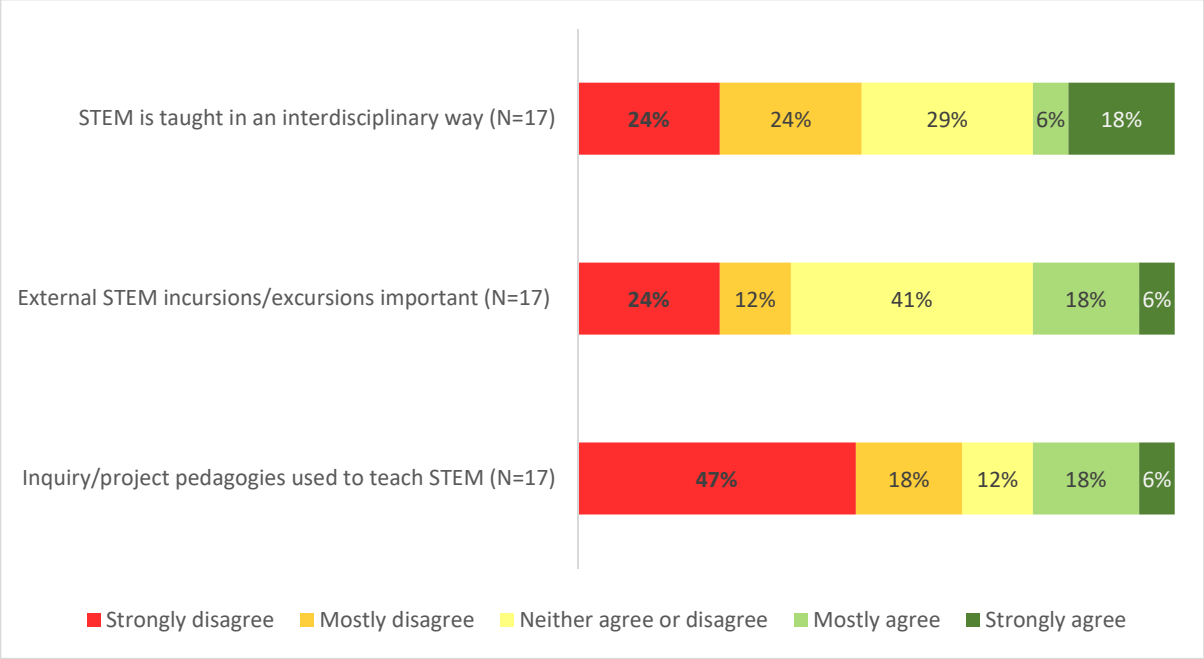


Notes: N=18 Source: Baseline Schools STEM Engagement Survey 2020

Overall, 17 schools responded to the questions on STEM learning practices in schools. One-quarter (24%) of schools reported using inquiry- or project-based pedagogy and an interdisciplinary (cross-curricular) approach to teaching STEM (**FIGURE 10**). This would suggest that there is an opportunity to increase teachers' knowledge and confidence to use these pedagogies. 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.[23,24,25]

Twelve percent of survey respondents perceived that STEM subjects were in demand by their students. Based on teacher perceptions, this could be an indicator of student interest in STEM or the quality of STEM teaching or a lack of STEM opportunities in schools.

FIGURE 10 STEM LEARNING PRACTICES IN SCHOOLS



Notes: N=17 Source: Baseline Schools STEM Engagement Survey 2020

[23] Regional Australia Institute & National Broadband Network (2016). The future of work: setting kids up for success. Canberra, Regional Australia Institute.
[24] Foundation for Young Australians (2017). The New Basics: Big data reveals the skills young people need for the New Work Order. (pp.7)
[25] 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

Ideally, there are "multiple access points that reflect the range of perspectives, backgrounds, and strengths of the diverse people who inhabit the learning ecosystem"[26]

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 offered across all age cohorts in a range of settings.

Data from providers and schools identified 30 diverse informal providers delivering school incursions and excursions.

Half of the surveyed informal STEM providers (53%, N=19) reported delivering 32 distinct community-based STEM activities reaching over 4,000 people.

Two-thirds of surveyed schools (64%, N=14) reported that teachers had received STEM professional development, noting this is not representative of all schools. Mostly, education authorities and conferences provided those opportunities.

IDENTIFIED GAPS OR CHALLENGES

Identified informal STEM programs and activities offered fewer programs aimed at early childhood and educator professional learning.

From our small sample of schools, less than half of schools (41%, N=17) received a STEM incursion or excursion in a typical year.

Digital or virtual offerings were uncommon.

Half the schools (50%, N=14) reported offering extra-curricular STEM activities.

One-quarter (24% N=17) of schools agreed that external STEM programs, incursions or excursions, were an important source of STEM learning for students in their school.

[26] 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 STEM incursions, excursions[27] and extra-curricular activities targeting all ages

School-based activities included both incursions and excursions. The study identified 30 informal STEM providers that delivered school-based activities in 2019 (FIGURE 11). Most were identified as cultural institutions, government, and education centres. All school stages were catered for with primary students most frequently targeted by activities (N=20). Nine providers targeted teachers or foundation/prep students.

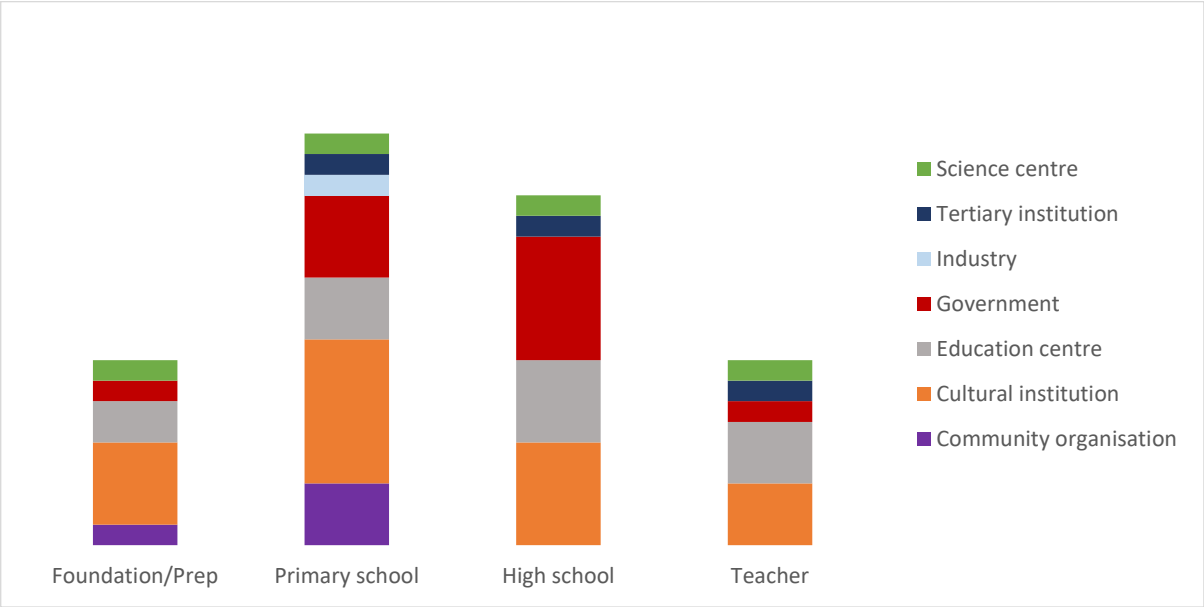
53% of our surveyed informal STEM providers (N=19) delivered a total of 29 distinct school-based activities in 2019, which were delivered a total of 89 times for over 1,100 students. Larger providers offered multiple activities.

Equatorial Launch Australia offers STEM engagement opportunities to schools in which students can take a picture of their school from space using satellites

Half of schools (50%, N=14) offered extracurricular programs; 29% had STEM clubs and 21% offered after-school or extension STEM programs. Extracurricular activities were offered more to primary than secondary school students.

One quarter (24%, N=17) of schools agreed that external STEM programs, incursions or excursions, were an important source of STEM learning for students in their school.

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



Notes: N=30 providers Source: Baseline Schools STEM Engagement Survey 2020; Baseline Informal STEM Providers Engagement Survey 2020

[27] 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)

Range of community-based STEM experiences targeting all ages

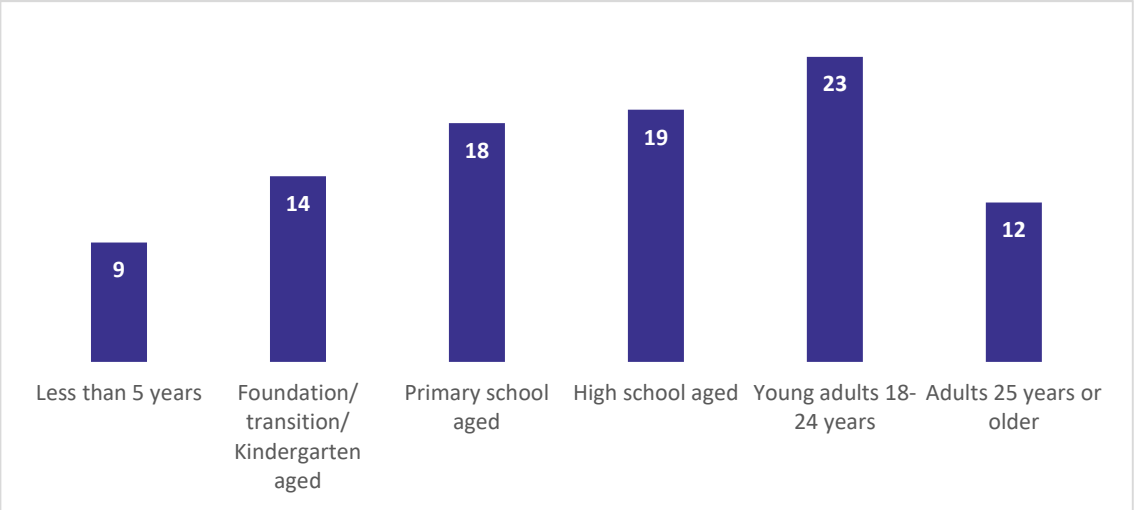
Non-school activities refer to community-based activities delivered outside of the school environment. Around half of surveyed informal STEM providers (53%, N=19) reported delivering 32 distinct non-school activities; some on multiple occasions. Activities targeted children of all ages and included *First LEGO League*, Robotics and Coding Clubs, Indigenous-led STEM workshops, events, festivals and fairs, and National Science Week. National Science Week was mentioned by nearly all providers.

Most activities targeted young people aged 18-24 (23 activities), followed by secondary school aged children (19 activities), and primary school aged children (18 activities) (**FIGURE 12**).

Six Seasons is a technology education initiative using drones and was developed by Aboriginal elders

Three STEM-based festivals were held in 2019, with providers hosting various activities. Combined, these activities reached 510 people. The highest level of participation was a virtual activity for the Eco Fair, where 300 people attended. For all other activities (not festivals), 3,742 people participated.

FIGURE 12 TARGET AGE GROUPS OF COMMUNITY STEM PROGRAMS IN 2019



Notes: N=10 providers, 32 activities. Activities may target more than one age group. Source: Baseline Informal STEM Providers Engagement Survey 2020.

Equitable reach of experiences

Geographic and demographic reach of STEM engagement was not captured because of the low response rate to the school survey. Still, less than half of surveyed primary and secondary schools (41%, N=17) reported receiving a STEM incursion or excursion in a typical year. Incursions and excursions mostly targeted Years 3-6 in primary and Years 9-10 in secondary.

Digital or mixed mode (hybrid) delivery models have potential to extend activity reach and create sustained, personalised and innovative learning experiences[28]. In 2019, digital delivery of STEM programs was uncommon and few providers had existing digital capacity.

Educator STEM professional learning opportunities

Two-thirds of schools (64%, N=14) reported teachers had attended formal STEM professional development in 2019, primarily offered through education authorities and conferences. However, professional learning reach was difficult to assess on the available evidence. Four (21%, N=19) of informal STEM providers surveyed delivered professional learning activities in 2019.

Interviews with formal education providers and educators identified a number of challenges for teachers undertaking professional development, including overloaded schedules that made it difficult to attend and then implement learnings. Professional learning was most likely to be implemented when follow-up was offered and when learning aligned with a school's subjects and timetabling.

[28] 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)

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[29]

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 'interactive' ecosystem.

Most informal STEM providers were 'aware' of each other but fewer had deeper connections – communication, coordination or collaboration.

There was a strong appetite to increase communication, coordination and collaboration across informal providers and with schools.

STRENGTHS

Most informal providers were engaging at the level of communication that is, information sharing.

Collaborative connections were more common between government organisations, cultural institutions (such as museums and libraries), tertiary institutions and science centres.

Several formal STEM networks with cross-membership were identified indicating a strong foundation for connecting the ecosystem.

IDENTIFIED GAPS OR CHALLENGES

Industry, community groups/organisations, and education centres tended to have fewer connections with other providers.

Less connected providers expressed a strong interest in more collaboration.

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

Results indicated a potential to promote the benefits of greater collaboration with industry.

[29] 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

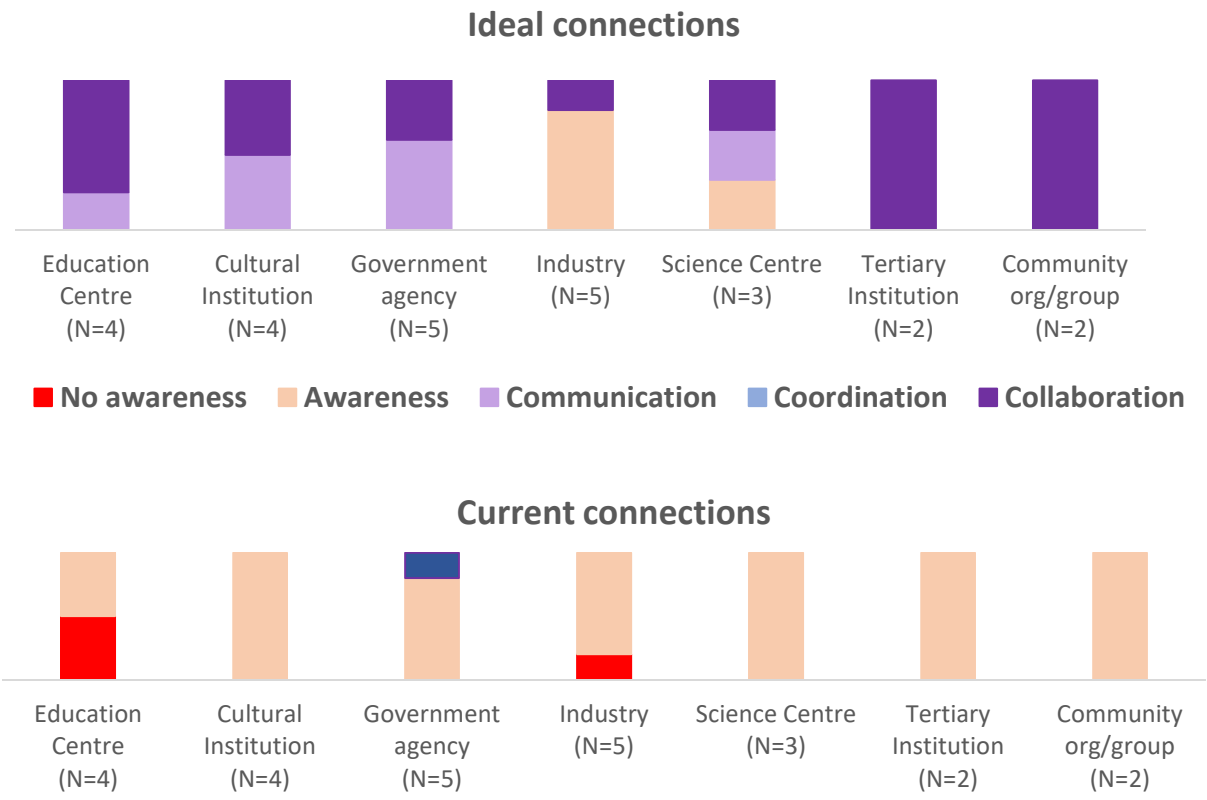
Type and strength of connections between STEM providers

Informal provider survey respondents rated their current and ideal level of connection with 25 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 provider respondents (N=17). Listed providers are de-identified and shown by type.

Providers were aware of each other but communication, coordination and collaboration were less common. Most providers wanted to increase their level of connectedness with other providers suggesting a strong appetite for expanding the network of organisations who are collaborating and coordinating activities. Interestingly, providers reported less interest in collaborating with industry.

FIGURE 13 CURRENT VS IDEAL LEVELS OF CONNECTIONS BETWEEN INFORMAL STEM PROVIDERS (N=12)



NOTES: N=17. Informal providers rated their current and ideal levels of connectedness with other providers against a list of 25 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 providers de-identified and shown by type. Source: Baseline Informal STEM Providers Engagement Survey 2020.

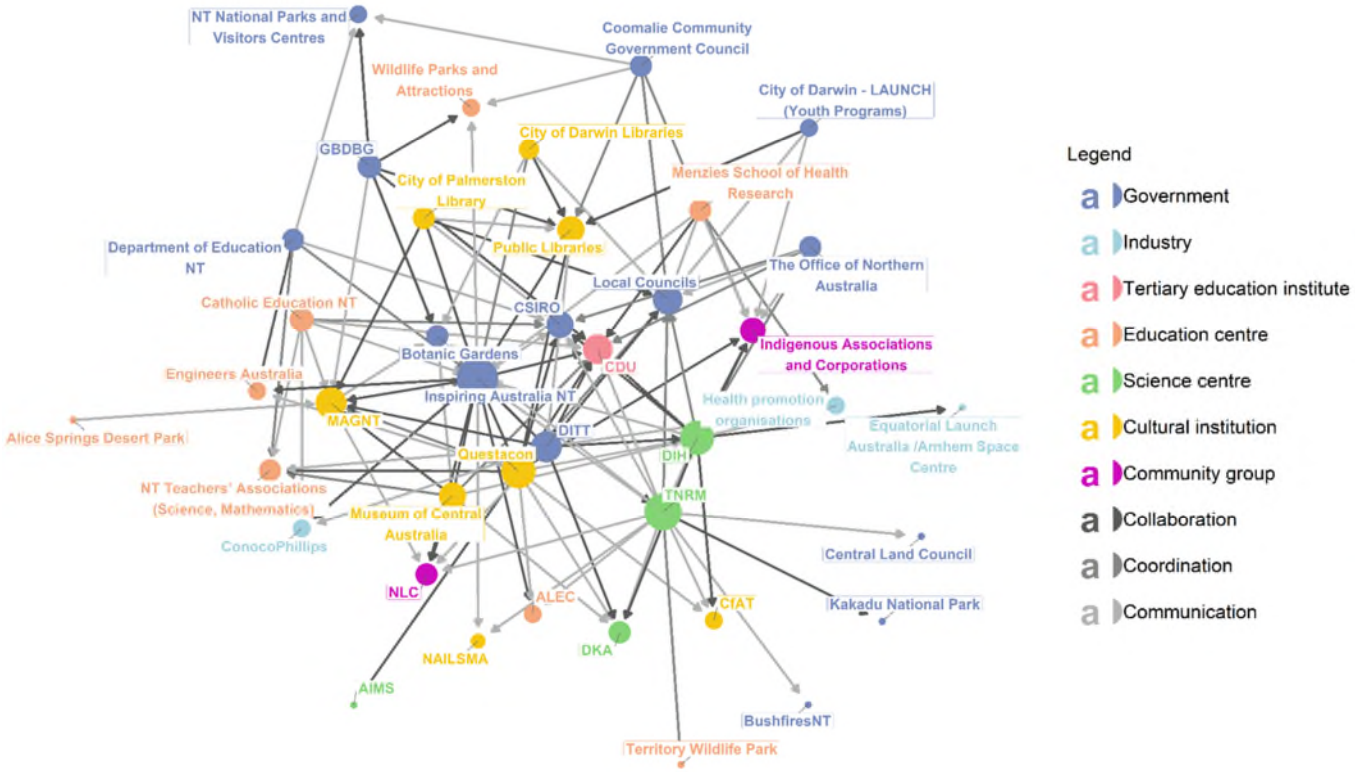
Cross-sector networks

Organisations connecting through either communication, coordination or collaboration are presented in the NT STEM network map (**FIGURE 14**).

The network map suggests a connected learning ecosystem. Most connections were focused on communication, although some providers reported coordinating and collaborating on activities. Collaborative connections were between government organisations and cultural institutions (such as museums and libraries), as well as tertiary institutions and science centres. Industry, community groups/organisations, and education centres tended to have fewer connections with other providers.

The diversity of informal providers means there were differences in terms of awareness and valuing connections as part of a broader ecosystem. An often-mentioned barrier for providers that lacked a level of connectedness was their lack of knowledge about potential collaborative initiatives or how to approach other providers to develop joint projects.

FIGURE 14 MAP OF NORTHERN TERRITORY STEM LEARNING ECOSYSTEM CONNECTEDNESS LEVELS



Source: Baseline Informal STEM Providers Engagement Survey 2020

NOTES ON NETWORK MAPS

The map of the Northern Territory STEM learning ecosystem shows whether providers work together at all (a line drawn between providers) and the nature of that connection. The direction of the arrow has a meaning. It 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 the definitions below). The black line denotes that the providers collaborate; the medium grey line that activities have been coordinated and the light grey line that the two organisations share information. The larger the dot, the more connections a provider has with other STEM providers.

Key to provider name abbreviations

- AIMS = Australian Institute of Marine Science
- ALEC = Arid Lands Environment Centre
- CDU = Charles Darwin University
- CSIRO = Commonwealth Scientific and Industrial Research Organisation
- CVA = Conservation Volunteers Australia
- CfAT = Centre for Appropriate Technology
- DIH = Darwin Innovation Hub
- DITT = Department of Industry, Tourism and Trade
- DKA = Desert Knowledge Australia
- GBDBG = George Brown Darwin Botanic Gardens
- MAGNT = Museum and Art Gallery of the Northern Territory
- NAILSMA = North Australian Indigenous Land and Sea Management Alliance
- NLC = Northern Land Council
- TNRM = Territory Natural Resource Management

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 other 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.

Formal networks

This study identified active networks and hubs where people and organisations could coalesce around common interests and share information, knowledge and learning. Inspiring NT participates in three key informal STEM networks, Inspired NT Network, National Science Week Organising Committee, and Business Innovation NT Network offering a solid foundation for building cross-sector networks.

Not all STEM providers were aware of these. Others described more informal networks, based on leveraging personal connections/long-standing relationships to support STEM activities. (See **Appendix 1** for more information on STEM networks).

Informal provider and school attitudes on collaboration

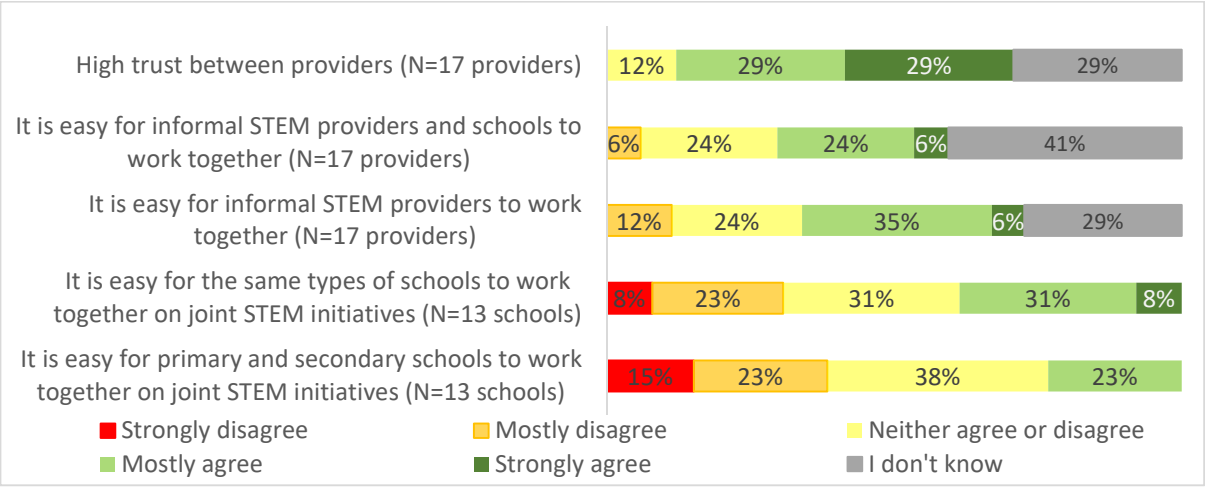
Surveyed informal providers and schools had mixed perceptions about how easy it was to work together. Just 41% (N=17) of surveyed informal STEM providers agreed '*it is easy for providers to work together*' and 29% reported '*I don't know*'. Half, (47%) agreed '*it was easy for informal providers and schools to work together*'. More than half of informal providers, (58%) reported '*high levels of trust between providers'* and 29% selected '*I don't know*'. Interviewees mentioned that working together was often reliant on personal connections.

> *"Our population is relatively small. A lot of things still work on who you know and who has relationships, and even down to who's got the trust of certain researchers and is happy to grant access to properties or Indigenous land to have research done. All these things are really critical in successful engagement and in successful project outcomes."*
>
> *[Informal STEM Education Provider]*

Less than one-third of providers (29%) believed '*local networks can demonstrate outcomes of collective work';* and 29% selected 'I don't know'. This may indicate low recognition of a collective mindset.

More schools agreed that it was easier to work on joint initiatives with the same types of schools (39%, N=13) than it was to work between primary and secondary schools (23%, N=13) (**FIGURE 15**).

FIGURE 15 STEM PROVIDER AND SCHOOL PERSPECTIVES ON WORKING TOGETHER



Notes informal providers N=17 and schools N=13 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 [30]

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.

STEM pathway programs and initiatives offered through school, the university, industry and informal STEM providers.

Interviewees identified that pathways could be better connected and more visible, particularly in remote areas.

STRENGTHS

The study identified several initiatives to strengthen STEM pathways offered through schools, post-school institutions, and informal learning settings.

Government investment plans in STEM infrastructure and post-school programs had potential to strengthen STEM pathways and opportunities.

The Department of Education had identified study/career pathways as a priority.

IDENTIFIED GAPS OR CHALLENGES

Stakeholders observed that improving the visibility of STEM learning pathways for schools, students and parents remained a significant challenge across the education sector, particularly in remote areas.

This study did not gather sufficient data to identify the strengths or gaps in navigating school-industry STEM pathways and the role of industry in partnering and investing in programs.

[30] 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. Half of surveyed secondary schools (50%, N=8) offered STEM related vocational education and training programs in their school (**TABLE 4**). In our small sample, none of the surveyed schools offered the Australian Government funded Trade Training Centres Program[31] or the national non-profit CareerTrackers Indigenous Internship Program[32]. Though, nothing can be inferred about the uptake of these programs across NT schools.

TABLE 4 STEM PATHWAY PROGRAMS IN SECONDARY SCHOOLS

STEM pathway opportunities	Offered	Not	Unsure	Total
Vocational education and training programs	4	4	0	8
School-based apprenticeships or traineeships in STEM industries	2	5	1	8
Pathways in Technology (P-TECH) Program[33]	1	6	1	8
Mentoring programs for STEM students	1	6	1	8
CareerTrackers Indigenous Internship Program	0	7	1	8
Trade Training Centres Program[34]	0	7	1	8

Source: Baseline NT Schools STEM Engagement Survey 2020.

Charles Darwin University (CDU) is a major provider of post-school education with campuses across the NT and in Sydney. CDU offers STEM education through both academic programs and vocational education, and recently acquired $250 million of federal funding to establish a new Health and STEM precinct in Darwin. It has 7 STEM focused academic centres:

- College of Engineering, IT & Environment including:
- The Energy and Resources Institute (including the Centre for Renewable Energy and the Advanced Manufacturing Alliance)
- Research Institute for the Environment and Livelihoods
- College of Health & Human Sciences (including the Health Immersive Virtual Education facility)
- Menzies School of Health Research
- Molly Wardaguga Research Centre
- The Northern Institute
- The Australasian Centre for Resilience Implementation for Sustainable Communities.

The Batchelor Institute, the only First Nations dual sector[35] tertiary education provider in Australia, offers vocational qualifications in STEM-related studies.

[31] National program to help students successfully move to further education, training or work. Trade Training Centres in Schools Program - Department of Education, Skills and Employment, Australian Government (dese.gov.au)
[32] CareerTrackers is a national program that creates paid internship opportunities for Indigenous students. CareerTrackers | CareerTrackers Indigenous Internship Program | CareerTrackers
[33] 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
[34] Trade Training Programs in Schools is a national program to help students successfully move to further education, training or work.
[35] Dual-sector education is a system of tertiary education that includes substantial amounts of both vocational (skills-based) and higher (academic-based) education in the same institution.

Informal STEM opportunities are also offered through several organisations to strengthen young people's visibility and understanding of STEM learning and career pathways.

Survey data showed 53% (N=17) informal STEM providers had a moderate to major focus on '*improving pathways to STEM careers*'.

Inspired NT (under the Inspiring Australia umbrella) provides opportunities for PhD and undergraduate university STEM students to go to primary schools and deliver workshops/ presentations about their projects

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

Interviewed STEM providers were of the opinion that STEM learner pathways were not well connected in the region and that creating and making visible STEM learning pathways remained the biggest challenge across the education sector. Despite improvements, providers said that there was a lack of coordination in developing learning pathways from schools to VET/tertiary education or non-formal education opportunities and/or STEM careers, and that these challenges were compounded by remoteness.

Interviewed providers also observed that students and their parents were not aware of the breadth of available STEM programs, pathways and careers, for example, that STEM careers are not only accessible through a university qualification, but through vocational education and training courses or trades, or industry-based training/programs.

CDU's Santos Science Experience, supported by ConocoPhillips and Santos, provides high school students the opportunity to engage in a wide range of science activities under the guidance of scientists in university settings

The study identified that the NT Department of Education was promoting a focus on STEM learning and career pathways in schools. One of the challenges was the differing priority of STEM across schools. Provider suggestions for strengthening STEM learning pathways between school and post-school studies, included:

- Increased career guidance in schools focused on not just on the requisite school grades, but the range of STEM pathways and institutions available and the skills/attributes to develop.
- Dedicated roles focused on improving learning pathways from early years to post-school education and training.

This study did not gather sufficient data to identify the strengths or gaps in navigating school-industry STEM pathways and the role of industry in partnering in programs. Interviewed providers perceived those local industries, for example, digital technology companies, were interested in working with schools

Conclusion

This study aimed to conduct a rapid assessment of the STEM learning ecosystem in the NT 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; Interconnected*.

What we found

Overall, the study findings indicated an 'interactive' STEM learning ecosystem across all 5 dimensions of *shared vision*, *capacity and resources, diversity and density of STEM-rich experiences*, *relationships* and *learning pathways*.

The Study found a diversity of providers and STEM experiences for schools and communities and a range of formal initiatives to strengthen STEM pathways. Providers perceived that formal and informal STEM learning pathways could be more visible and strengthened to improve uptake of learning opportunities, particularly in remote settings. While the sample of schools was small and Darwin-centric, survey and interview data indicated opportunities to strengthen school and educator STEM capabilities, practices and resources.

Providers had mixed views on the presence of a shared vision for STEM and wide interest in the idea of a shared vision. Providers had awareness of other organisations and shared information. There was appetite for greater coordination and collaboration across informal providers and schools to realise a shared vision and improve connectivity across the learning ecosystem.

What next

This snapshot of the STEM learning ecosystem in the NT 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 NT STEM PROVIDERS AND NETWORKS

Provider name	Type	Presence
Northern Land Council (NLC)*	Community group	Territory
Environment Centre NT	Community group	Territory
RoboCup Junior Australia	Community group	National
Skype a Scientist	Community group	International
The Mad Scientist	Community group	National
Questacon	Cultural institution	National
Centre for Appropriate Technology (CfAT)*	Cultural institution	Territory
Northern Australian Indigenous Land and Sea Management Alliance (NAILSMA)*	Cultural institution	Territory
George Brown Darwin Botanical Gardens (GBDBG)	Cultural institution	Territory
Alice Springs Botanical Gardens	Cultural institution	Territory
Sydney Botanical Gardens (Online)	Cultural institution	Interstate
City of Darwin Libraries	Cultural institution	Territory
City of Palmerston Library	Cultural institution	Territory
Museum and Art Gallery of the NT (MAGNT)	Cultural institution	Territory
Museum of Central Australia	Cultural institution	Territory
Alice Springs Desert Park	Education centre	Territory
Crocosaurus Cove	Education centre	Territory
Territory Wildlife Park	Education centre	Territory
One Giant Leap Australia Foundation	Education centre	National
Arid Lands Environmental Council (ALEC)	Education centre	Territory
Six Seasons Drone School*	Education centre	Territory
NT Digital Technologies Roadshow	Education centre	Territory
Engineers Australia	Education centre	National
Menzies School of Health Research	Education centre	Territory
National Science Week	Education centre	National
The Academy of Science	Education centre	National

Provider name	Type	Presence
Australian Science Teachers Association	Education centre	National
NT Teachers' Associations (Science, Mathematics)	Education centre	Territory
SACE Online	Government	Interstate
ANSTO Online	Government	National
CSIRO	Government	National
The Office of Northern Australia	Government	Interstate
Central Land Council*	Government	Territory
City of Darwin - LAUNCH (Youth Programs)	Government	Territory
Coomalie Community Government Council	Government	Territory
Kakadu National Park	Government	Territory
NT Department of Industry, Trade and Tourism (DITT)	Government	Territory
NT National Parks and Visitors Centres	Government	Territory
NT Department of Environment, Parks and Water Security	Government	Territory
NT Department of the Chief Minister, Biosecurity Division	Government	Territory
NT Department of Health	Government	Territory
Royal Darwin Hospital	Government	Territory
Inspired NT	Government	National
Bushfires NT	Government	Territory
Fisheries NT	Government	Territory
Power and Water NT	Industry	Territory
Equatorial Launch Australia/ Arnhem Space Centre	Industry	Territory
ConocoPhillips	Industry	National
Rio Tinto	Industry	National
Caniffe Satellites	Industry	International
The Lego League	Industry	International
Australian Institute of Marine Science (AIMS)	Science centre	National
Darwin Innovation Hub (DIH)	Science centre	Territory
Desert Knowledge Australia (DKA)*	Science centre	Territory

Provider name	Type	Presence
Territory Natural Resource Management (TNRM)	Science centre	Territory
James Cook University	Tertiary education institution	Interstate
Charles Darwin University (CDU)	Tertiary education institution	National
Batchelor Institute*	Tertiary education institution	Territory

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.

Formal and informal networks and hubs

Inspired NT Network – Inspiring Australia, a National initiative, facilitates a network in the region to improve the coordination of STEM engagement activities. This network was described by interviewees as strong and well-connected, receiving funding from the NT Government and the Federal Government. Interviewees said that many STEM events and resources were produced through Inspired NT.

National Science Week Organising Committee – The National Science Week's NT Organising Committee was described by other interviewees as including leaders in informal STEM education in the region. The NT Department of Education and the City of Darwin were also involved in National Science Week.

Business Innovation NT Network – The NT Department of Industry, Tourism and Trade host a network of businesses, start-ups and entrepreneurs interested in pursuing innovation in their business and/or guiding and mentoring innovation by others. The network offers access to and potential collaboration with new companies, experienced business leaders, researchers, government, and investors.

Darwin Innovation Hub – a partnership between CDU, the NT Government, investment firm Paspalis, and the Federal Government's AusIndustry. The two venues— in Darwin and Alice Springs—offer a network of mentors, investors, industry experts to support local start-ups. It also collaborates with the Centre for Appropriate Technology, an Aboriginal and Torres Strait Islander organisation that delivers technological training; and Equatorial Launch Australia, one of Australia's first commercial space launch facilities.

Formal education networks included:

Professional Teachers' Association of the NT – provides and makes visible professional learning opportunities and facilitates networking for STEM teachers.

Department of Education STEM network – supports STEM teachers in planning STEM education activities.

Other networks discovered through a desktop review:

Women's Innovation Network NT – seeks to facilitate pathways to encourage and attract girls and young women into STEM and increase the availability and visibility of support and development opportunities.

Innovation Network – led by NTG Department of Industry, Tourism and Trade that includes a number of smaller networks.

NT Energy Innovation Network – identifies opportunities for mentoring and renewable energy workforce development.

NT Drones Network – members collaborate to provide services and increase opportunities through identifying training, assisting in mentoring, and facilitating innovation.

APPENDIX 2 BIBLIOGRAPHY

Reports and articles

Australian Department of Education (2016) Quality Schools, Quality Outcomes, https://www.dese.gov.au/quality-schools-package/resources/quality-schools-quality-outcomes

Australian Education Council (2015) National STEM School Education Strategy 2016-2026, https://www.dese.gov.au/australian-curriculum/support-science-technology-engineering-and-mathematics-stem/national-stem-school-education-strategy-2016-2026

Dandolopartners (2020) Evaluation of Early Learning and Schools Initiatives in the National Innovation and Science Agenda, https://www.dese.gov.au/national-innovation-and-science-agenda/resources/evaluation-early-learning-and-schools-initiatives-national-innovation-and-science-agenda

Darwin High School (2019) Darwin High School Master Plan, https://darwinhigh.nt.edu.au/uploads/Resource%20Downloads/Darwin%20High%20School%20FINAL%20plan.pdf

Engineers Australia (2018) Systemic Collaboration Case Study, https://www.engineersaustralia.org.au/sites/default/files/2019-03/sySTEMic%20Collaboration%20Case%20Study.pdf

Minerals Council of Australia (2018) Submission to the Optimising Stem Industry School Partnerships: Inspiring Australia's Next Generation Issues Paper, https://www.minerals.org.au/sites/default/files/MCA%20submission%20-%20Optimising%20STEM%20Industry-School%20Partnerships%20-%206%20February%202018.pdf

Nightcliff Primary School (2019) Nightcliff Primary Annual Report to the School Community, https://irp-cdn.multiscreensite.com/6d8b67bf/files/uploaded/Nightcliff%20Primary%20Annual%20Performance%20Report_2019.pdf

NT Department of Education (2018) STEM in NT Strategy 2018-2022, https://education.nt.gov.au/__data/assets/pdf_file/0011/591950/STEM-Territory-18-22-web.pdf

NT Department of Education (2018) STEM School Matrices, https://education.nt.gov.au/__data/assets/pdf_file/0010/937972/stem-schools-matrices.pdf

NT Department of Education (2019) NT Preschool Curriculum, https://education.nt.gov.au/__data/assets/pdf_file/0012/359778/preschool-curriculum-revised-2018-version.pdf

Sattar, F. (2019) Drone-based Experimental Learning and STEM Education, Charles Darwin University, https://ris.cdu.edu.au/ws/portalfiles/portal/34079400/Drone_Based_Experiential_Learning_and_STEM_Education_CDUWebPortal_1.pdf

Press releases

NT Department of Education (2018) PR1MEd to Master Maths, https://education.nt.gov.au/news/2018/pr1med-to-master-maths

NT Government Newsroom (2018) Building up STEAM: Investing in Our Future with New Facilities for Rural Students, https://newsroom.nt.gov.au/mediaRelease/24233

NT Government Newsroom (2018) Full STEAM Ahead: Tender Announced for Darwin High School STEAM Centre, https://newsroom.nt.gov.au/mediaRelease/25423

NT Government Newsroom (2020) State-of-the-art new STEM Centre for Casuarina Senior College, https://newsroom.nt.gov.au/mediaRelease/33824?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news

Learning resources and brochures

Casuarina Senior College, Skilling Australia Foundation (2018) Casuarina Senior College Top End P-TECH Partnership, https://www.ptech.org.au/wp-content/uploads/P-TECH-local-brochure-Top-End-Jan-2019.pdf

Centre for School Leadership (2017) Leading Teaching Certification in STEM 2017 Program, https://www.cdu.edu.au/sites/default/files/csl/docs/csl-stem.pdf

Cohrssen, C. (2013) NT Preschool: Maths Games, NT Department of Education, https://nt.gov.au/__data/assets/pdf_file/0006/815568/maths-learning-games.pdf

Guarrella, C., Stewart, L. & Cohrssen, C. (2018) NT Preschool: Science Games, NT Department of Education, https://education.nt.gov.au/__data/assets/pdf_file/0020/673202/nt_science_games.pdf

Hill, G., Guarrella, C. & Cohrssen, C. (2019) NT Preschool: Engineering Games, NT Department of Education, https://education.nt.gov.au/__data/assets/pdf_file/0003/810858/nt-engineering-games.pdf

Stewart, L., Hill, G. and Cohrssen, C. (2020) NT Preschool: Technology Games, NT Department of Education, https://education.nt.gov.au/__data/assets/pdf_file/0005/810860/nt-technology-games.pdf

Webpages

Australian Curriculum, Assessment and Reporting Authority (2019) National Report on Schooling in Australia, https://www.acara.edu.au/reporting/national-report-on-schooling-in-australia

Australian Department of Industry, Science, Energy and Resources (2020) Inspiring Australia: Science engagement in Australia, https://www.industry.gov.au/funding-and-incentives/inspiring-australia-science-engagement-in-australia

Australian Department of Industry, Science, Energy and Resources (2020) STEM Equity Monitor, https://www.industry.gov.au/data-and-publications/stem-equity-monitor

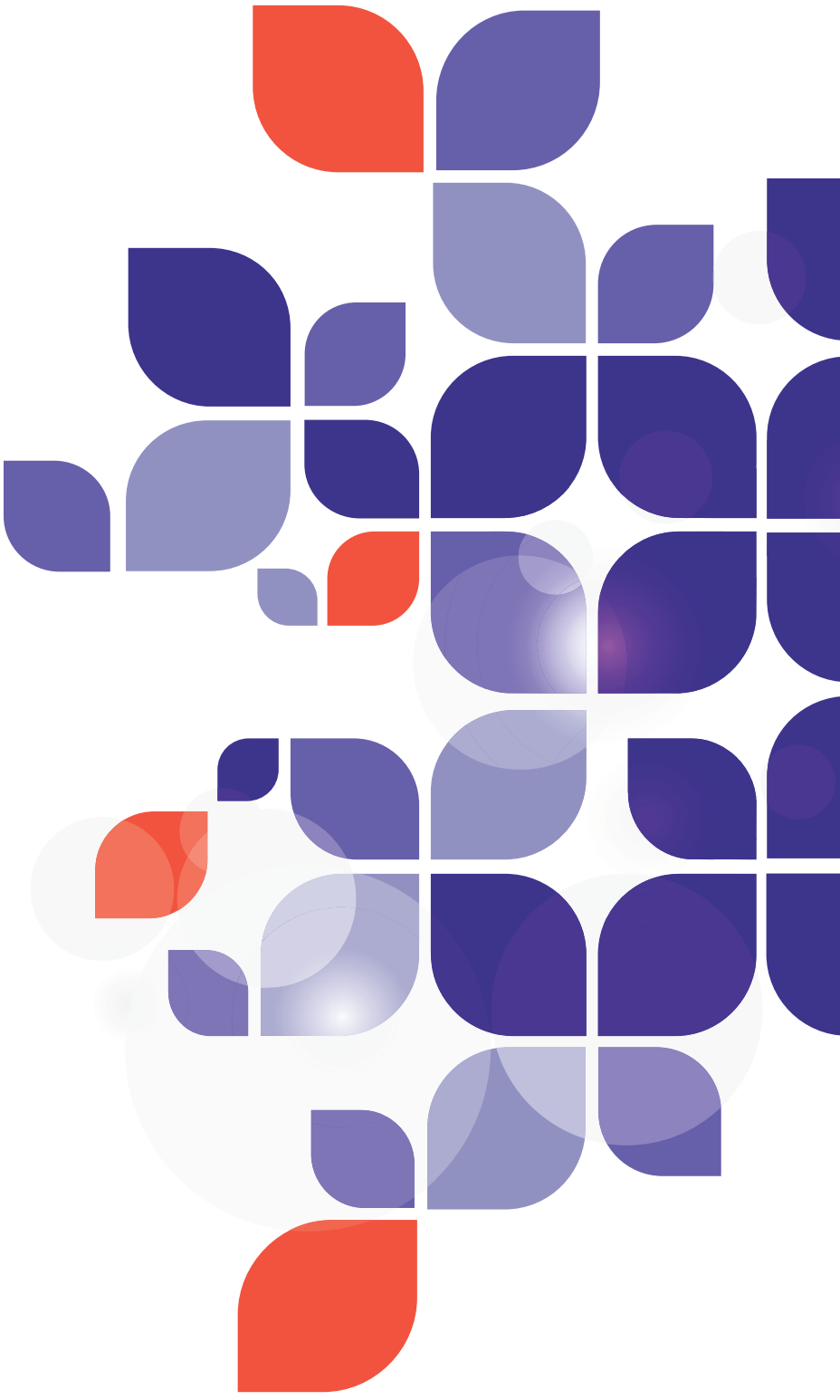
Business Australia (2020) Grants to boost girls' and women's participation in STEM and entrepreneurship, https://business.gov.au/grants-and-programs/women-in-stem-and-entrepreneurship

COOLmob and Arid Lands Environmental Centre (2019) COOLmob Energy Efficient Project, https://www.coolmob.org/coolmob_energy_efficient_project

Inspired NT (2020) National Science Week Grants, https://www.inspirednt.com.au/events-activities/national-science-week-grants/

Maths Enrichment Camps, MTANT Inc. (2018) http://mtant.weebly.com/maths-enrichment-camps.html

Whole of Community Engagement Initiative (2015) https://remotengagetoedu.com.au/



Questacon – The National Science and Technology Centre
Tel: 02 6270 2800

www.questacon.edu.au