Identifying opportunities for addressing the dimensions of STEM

Julie King

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acara AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

Overview

- STEM in the Australian Curriculum
- STEM practices and STEM dimensions
- Finding a connecting idea
- Making the tacit explicit – enhancing transfer
- Developing connections and preparing a pitch
- Resources

STEM Connections

https://www.australiancurriculum.edu.au/resources/stem/

Overview

ACARA's STEM Connections project aimed at investigating a cross-disciplinary approach to the teaching of STEM disciplines. In collaboration with the Australian Association of Mathematics teachers, ACARA supported 13 schools from around the country to develop an integrated STEM project that had its basis in the real world and incorporated the Australian Curriculum learning areas of Mathematics, Science and Technologies. While the project was implemented before the publication of the *National STEM School Education Strategy*, it addressed the stra five key areas for national action.

The STEM Connections report, illustrations of practice and work samples available on this page are products of the project. The illustrations of practice explo schools and the work samples provide examples of integrated STEM tasks.

The interdisciplinary nature of STEM in these projects is evident. While annotations for work samples have been identified as one or other of the Australian C Technologies, Mathematics), it is important to note that the skill is often developed in all three. As engineering is addressed across the curriculum through Sc dedicated content description focusing on engineering principles and systems at each band in Design and Technologies, content relating to engineering is id Curriculum learning area for each project.

You will find a link to the STARportal below. The STARportal is Australia's national portal for exciting and engaging STEM activities from around the country. students and teachers with their local and online STEM activities in real time.

Further work on STEM Connections has been undertaken as part of ACARA's Digital Technologies in focus project. The new additions include: a critiquing cl project; reflective podcasts and a new F-2 Illustration of practice. Further illustrations of practice Years 3-8 are planned.

STEM Connections report

STEM planning and critiquing

STEM Illustrations of practice, vodcasts and reflective podcasts

STEM work sample portfolios

Sustainability

Environment

Product

Force and motion

Illustrations of practice

Introduction

In 2015 ACARA recorded and published five illustrations of practice for STEM Connections in Years 9-10.

As a part of the Digital Technologies in focus project, five new illustrations of practice for STEM Connections are being developed. Further illustrations of practice for Years 3-8 are planned.

St Stephen's Primary School (Years 1 and 2)

Mandurama Public School (Years K to 6)

Drummond Memorial Public School (Years 5 and 6)

Walcha Central School (Years 5 and 6)

Northcote High School (Years 7 to 10)

Cherrybrook Technology High School (Years 9 and 10)

STEM in the Australian Curriculum

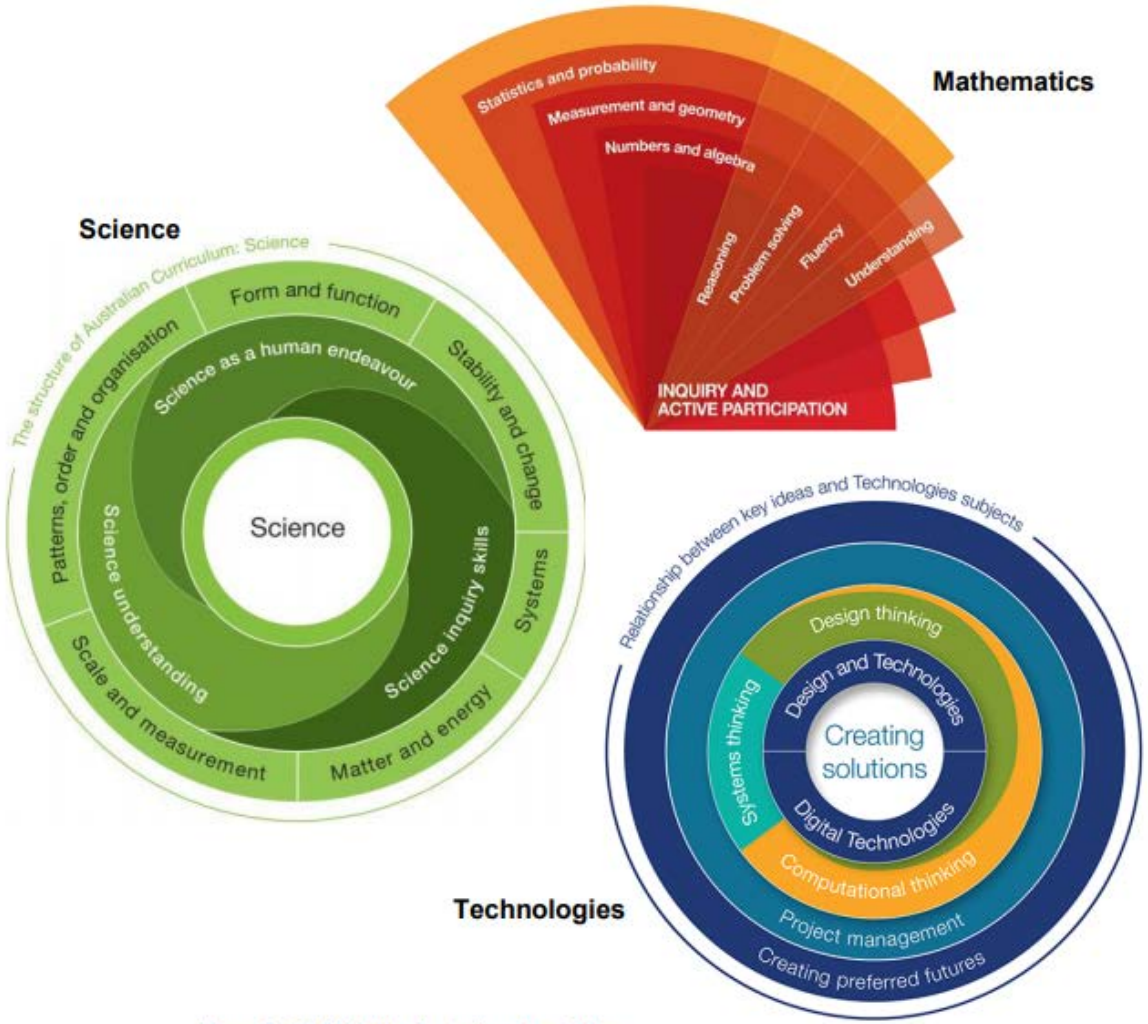

Figure 3. STEM in the Australian Curriculum

Engineering in the Australian Curriculum

Addressed:

- across the curriculum through Science, Technologies and Mathematics
- in Design and Technologies through a content description at each band focused on engineering principles and systems.

Engineering 'contextualises mathematics and science principles and processes, but can also enrich students' learning in their studies of technology, literacy, history and geography.' (English et al., 2012: 2)

STEM, enterprise, futures

Opportunities for STEM:

- exist within learning areas themselves (disciplinary)
- are strengthened when the connections between learning areas are emphasised (interdisciplinary)
- are richest when learning areas combine to find authentic learning opportunities for students in answer to an identified problem or in the creation of a solution (transdisciplinary).

Creating preferred futures – the overarching key idea of the Australian Curriculum: Technologies

STEM PRACTICES AND STEM DIMENSIONS

STEM practices

A conceptual framework for teachers to design transdisciplinary STEM Connections units that focus on the Australian Curriculum: Science, Technologies and Mathematics.

Students develop STEM practices (ways of thinking, knowing and doing) by addressing:

- STEM dimensions:
  - Relationships
  - Patterns
  - Structure and function
  - Systems
  - Measurement and data
  - Modelling and models.

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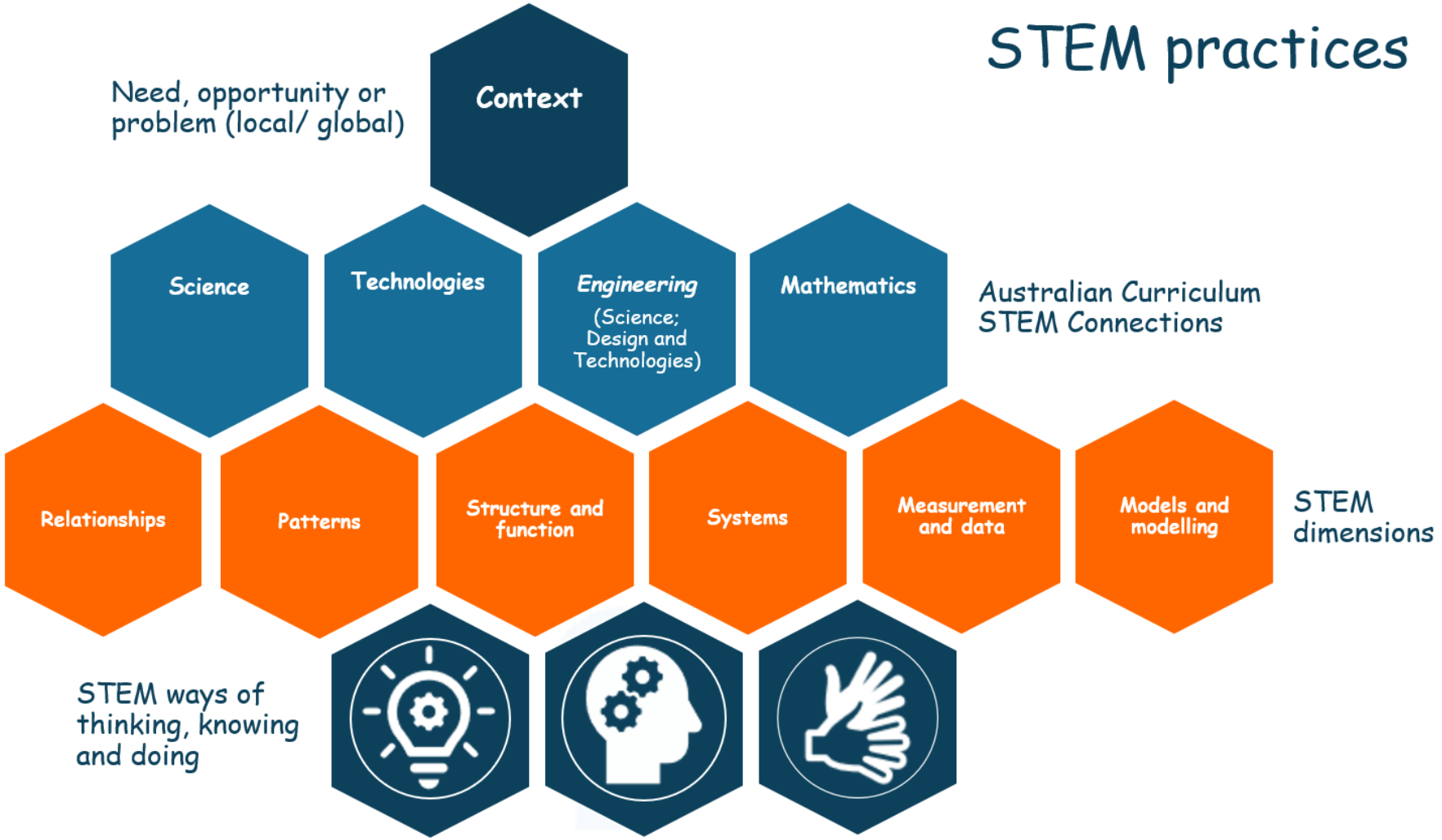
STEM practices



Dimensions

Relationships: an understanding of how ideas, things or events are related to one another; for example, how causality (one event or action is the direct result of another) or equivalence is crucial to problem-solving and designing solutions. This dimension underpins the other dimensions.

Patterns: an ability to recognise, describe, create and visualise patterns; make predictions based on observations; and see connections and make generalisations.

Structure and function: an understanding of how the physical or abstract form of objects, systems or processes (including sub-structures, organisation and hierarchy) relate to their function or purpose.

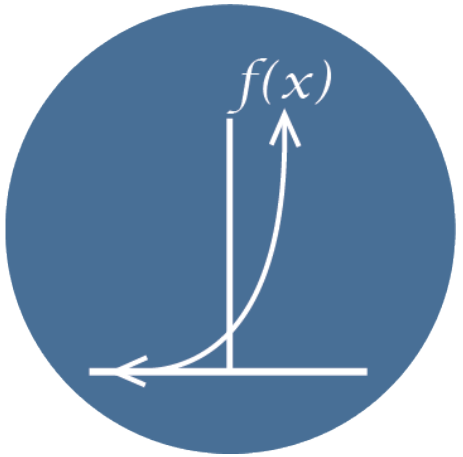
Systems: an understanding of how interconnected procedures and or components are organised and work together (objects, processes and concepts) and the ability to abstract the relevant details of these systems according to the situation.

Measurement and data: an ability to collect and analyse information that provides insight, allows for formation of theories and influences design and iteration.

Models and modelling: a representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea; and the ability to create physical, mathematical or conceptual models that may enhance problem-solving.

Relationships

Assess if there are opportunities for students to:



consider cause and effect

explore the impacts of change

'Cause and effect are two sides of one fact'

Ralph Waldo Emerson (1803–1882)

compare and contrast

consider alternative perspectives

predict and infer

respond to feedback to inform decisions

Patterns

Assess if there are opportunities for students to:

consider patterns or repeated events when making decisions

sort, classify and explain patterns

'the best designers will use many patterns that dovetail and intertwine to produce a greater whole'

Erich Gamma (1961–)

make connections within and between Science, Technologies, Engineering and Mathematics

consider functions, rules and relationships

make predictions or generalisations from identified patterns

Structure and function

Assess if there are opportunities for students to:

recognise how form and function inform systems and processes

consider purpose and function when designing solutions

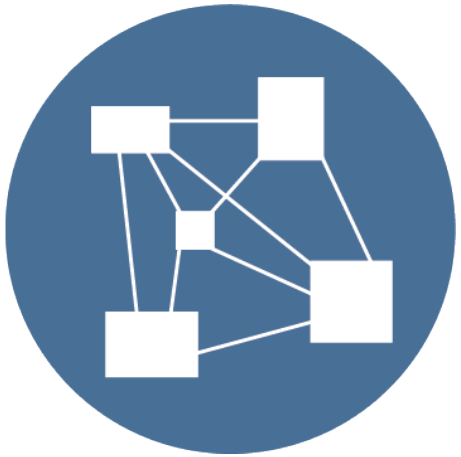
test and use materials, systems, components, tools or equipment

'Form follows function – that has been misunderstood. Form and function should be one, joined in a spiritual union.'

Frank Lloyd Wright (1867–1959)

Systems

Assess if there are opportunities for students to:



identify and describe the components of systems

make connections and transfer knowledge to real-world applications

'In nature, nothing exists alone.'

Rachel Carson (1907–1964)

consider the impact of system components on each other

explore and analyse the interactions between components

Measurement and data

Assess if there are opportunities for students to:

reflect on validity and reliability of data

use appropriate units of measurement

'Without data, you're just another person with an opinion'

W. Edwards Deming (1900–1993)

collect, interpret and present data

use data to inform decisions for designed solutions

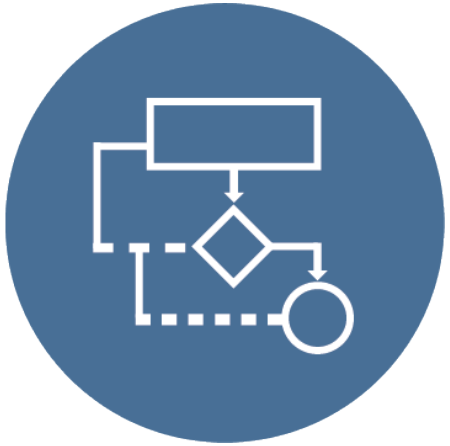
identify patterns in data

use data to predict and infer

investigate and define needs, opportunities or problems

Models and modelling

Assess if there are opportunities for students to:



use models (mathematical, physical, conceptual) to communicate ideas and solve problems

'Prototyping is the conversation you have with your ideas'

Tom Wujec (1959–)

explore 'what if…?' questions using models or simulations

use models to examine alternative perspectives and to see new opportunities

prototype to explore ideas and plans for designed solutions

simulate systems

https://digitalcareers.csiro.au/en/Career-spotlights/Kate-Patterson

Critiquing checklist

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STEM dimensions critiquing checklist

Overview

The purpose of this critiquing checklist is to scaffold a critique of a Science, Techr Engineering and Mathematics (STEM) Connections unit of work or project using tl dimensions. In a STEM Connections unit of work or project, students develop STE practices (STEM ways of thinking, knowing and doing) by addressing the STEM d

Relationships: an understanding of how ideas, things or events are related to on for example, how causality (one event or action is the direct result of another) or e is crucial to problem-solving and designing solutions. This dimension underpins th dimensions.

Patterns: an ability to recognise, describe, create and visualise patterns; make pr based on observations; and see connections and make generalisations.

Structure and function: an understanding of how the physical or abstract form of systems or processes (including sub-structures, organisation and hierarchy) relate function or purpose.

Systems: an understanding of how interconnected procedures and or component processes and concepts) are organised and work together, and the ability to abstr relevant details of these systems according to the situation.

Measurement and data: an ability to collect and analyse information that provide

STEM dimensions critiquing checklist

Once you have developed a STEM Connections unit, use the following points to check the depth and rigour in terms of STEM dimensions. The list is not exhaustive but may provide prompts to think more deeply about the opportunities for learning about and applying each dimension.

Dimension Assess if there are opportunities for students to:	**Evident** (Yes/No)	If yes, how is it addressed? If no, how could it be addressed?
Relationships • consider cause and effect • compare and contrast • respond to feedback to inform decisions • predict and infer • consider alternative perspectives • explore the impact of change		
Patterns • sort, classify and explain patterns • make connections within and between Science, Technologies, Engineering and Mathematics • make predictions or generalisations from identified patterns • consider functions, rules and relationships • consider patterns or repeated events when making decisions		
Structure and function • recognise how form and function inform systems and processes • consider purpose and function when designing solutions		

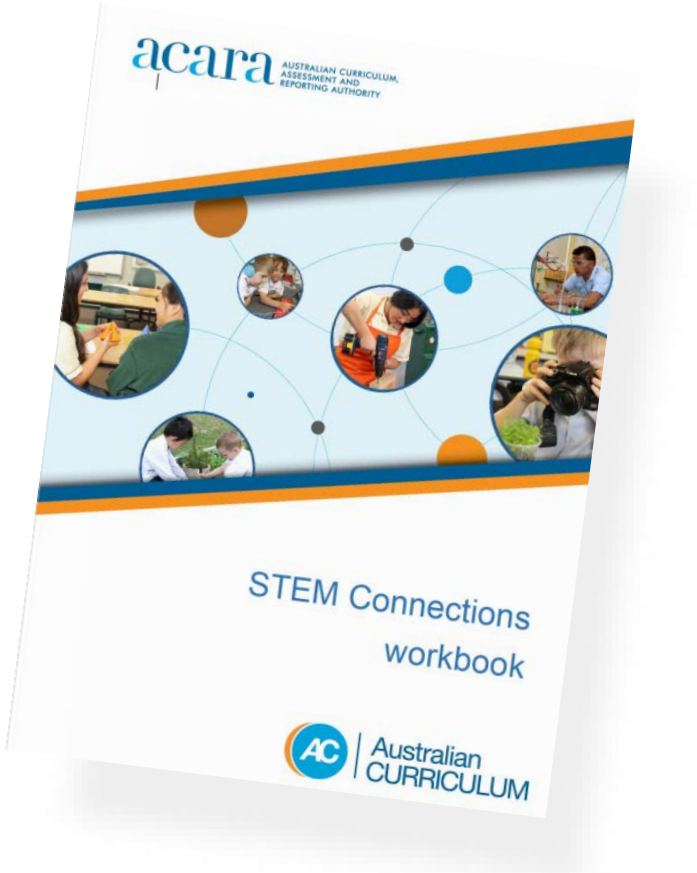
FINDING A CONNECTING IDEA

When connections are made between learning areas and subjects, there are opportunities for students to apply and transfer discipline knowledge, understanding and skills.

Criteria for success

- STEM connections are ***authentic*** and ***meaningful*** for the cohort of students
- The ***integrity*** of subjects is maintained
- The unit of work ***reflects the Australian Curriculum***
- The student activities ***enhance transfer***
- The assessment tasks ***reflect*** aspects of the Australian Curriculum ***achievement standards***

STEM Connections workbook

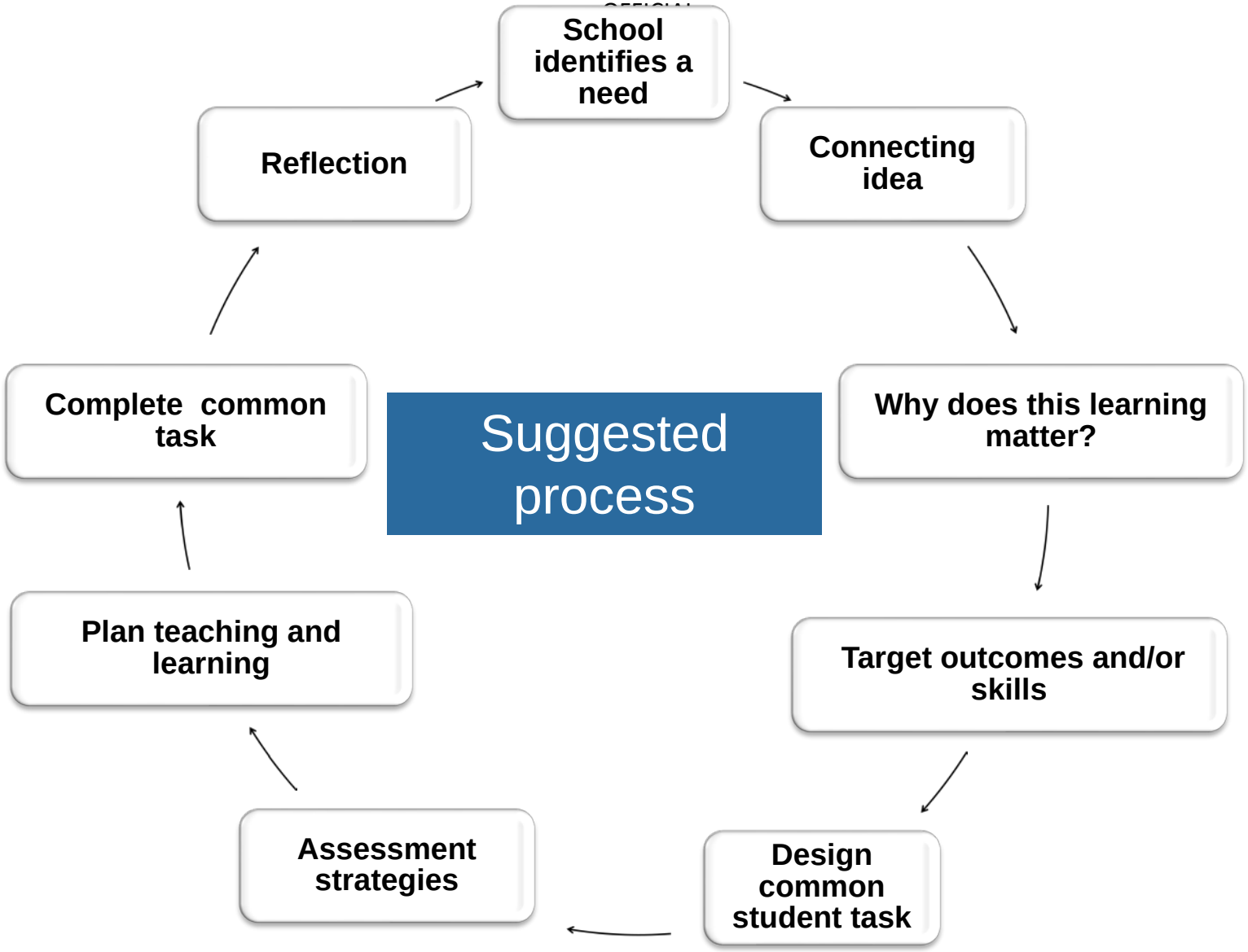


STEM Report/Support Documentation https://www.australiancurriculum.edu.au/resources/stem/

Step 1: Purpose

Determine the school identified purpose

- What is your school hoping to achieve by undertaking a STEM connection approach?
- What does the data tell you about this cohort of students?



(NSW DET 2008: Integrated Learning)

- The school identifies an **authentic need** – *what do you want your students to learn?*
- Teachers design a unit of work for approximately one term, for a chosen group of students based on the identified need.
- A **connecting idea** links the different subjects together.
- Students are given a **common task** to complete over the term.
- The task encourages students to make deep connections within and between subjects.
- Teachers **collaboratively plan** learning experiences to allow students to achieve the task.
- Teachers **select and assess outcomes from their own curriculum** which are appropriate to the connecting idea.
- Teachers program individual subject content and assessment.

Step 2: Connecting idea

- What concept, theme or idea will link the different subjects together?
- What knowledge and skills do you want the students to be left with once the unit has been completed?
- What do you normally teach during this timeframe?
- Does the learning connect to the students' world? Does it form a basis for future learning?
- Why teach this connecting idea? Why does it matter for students to gain a deep understanding of this concept?

Sample connecting ideas: Primary

- **Drummond Memorial Public School**: Students investigated engineering themes through a novel study and designed and built their own model wind turbines. Students tested the efficiency of their wind turbines by collecting and analysing data through the use of micro:bits

- **Mandurama Public School**: Students focused on food and fibre production through a smart garden. Students determined the success of each growing season by comparing wicking and non-wicking garden beds; using micro:bits to measure current to indicate whether the garden beds were wet or dry; and comparing data from each bed to determine which garden bed design was better for growing plants in their region.

https://www.australiancurriculum.edu.au/resources/stem/

Secondary

- **Heathfield High School**: School–business partnership, brokered by the Australian Industry Group. The school used this partnership to set the direction for the project and the project brief for students: to create a new product that would appeal to the youth market.

- **Cherrybrook Technology High School:** Students addressed the degradation of the top playground. They were given a design brief to identify issues affecting the top playground and design a potential solution for the targeted area. Science and Mathematics teachers took the Technology class whenever learning-area-specific teaching was needed.

https://www.australiancurriculum.edu.au/resources/stem/

Activity: Connecting idea

- Go to Jamboard: https://jamboard.google.com/d/11Yoht9w9-s68mUwH5j-0IrAwwS6zbPElnGBMBWzcuHQ/viewer
- Use the post-it notes tool to add ideas for connecting ideas
- Continue to add ideas through the workshop

STEM connecting ideas

MAKING THE TACIT EXPLICIT – ENHANCING TRANSFER

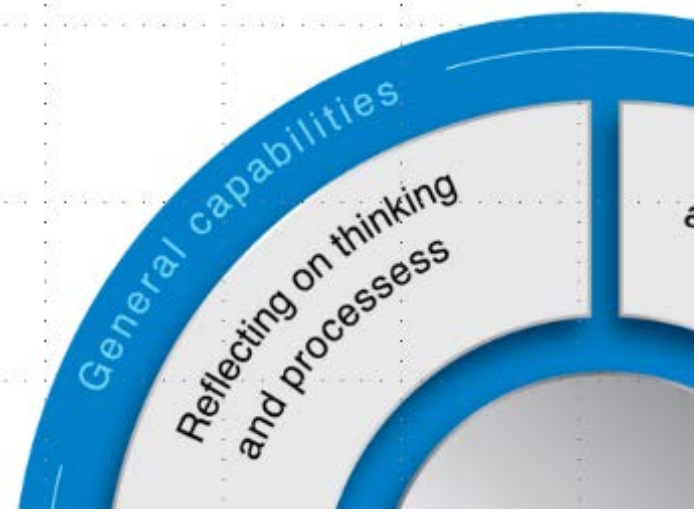
Enhancing transfer

Schools are supposed to be stopovers in life, not ends in themselves. The information, skills, and understandings they offer are knowledge-to-go. Not just to use on site.

(Perkins and Salomon, 2012: 248)

Reflecting on thinking and processes

- This element involves students reflecting on, adjusting and explaining their thinking and identifying the thinking behind choices, strategies and actions taken.
- Students think about thinking (metacognition), reflect on actions and processes, and transfer knowledge into new contexts to create alternatives or open up possibilities.
- They apply knowledge gained in one context to clarify another.
- In developing and acting with critical and creative thinking, students:
  - think about thinking (metacognition)
  - reflect on processes
  - transfer knowledge into new contexts.



Developmental progression and transfer

> *'Long-term learning within a domain often involves the development of more sophisticated understandings of subject matter, increasingly deep knowledge (for example, a growing appreciation of the contexts to which knowledge can be transferred and applied), and a developing ability to apply understandings and knowledge in real-world contexts'* (Masters, 2013: 35)

By progressively developing students' critical and creative thinking skills when working within and between disciplines we increase the likelihood of transfer and deep knowledge and understanding.

Explicit teaching during projects

Project conception to realisation

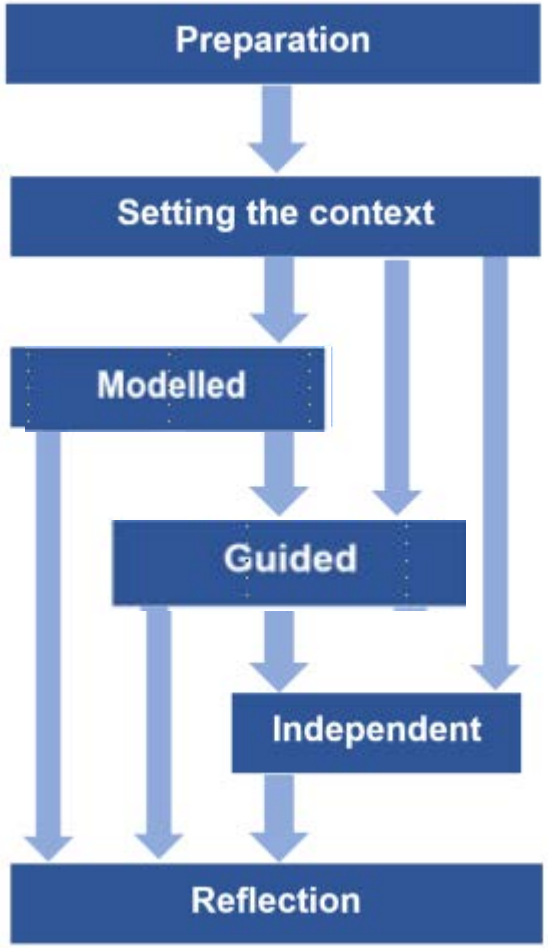
The phases of explicit teaching include:

- planning
- setting the context
- modelled teaching
- guided learning
- working independently
- reflection.

Cook, P., Quality Teacher Program (NSW) and Australian Government Department of Education, Science and Training (2002: 47)

Moving students from:

- Modelled to Guided to Independent



DEVELOPING CONNECTIONS AND PREPARING A PITCH

The pitch

The purpose of this activity is to develop and refine STEM connection ideas and to prepare a ‘pitch’.

- Develop connections and ideas for a project using the STEM Connections workbook.
- Prepare a ‘pitch’.
- Present the pitch at least twice to other people.
- Refine the pitch based on the feedback you receive.

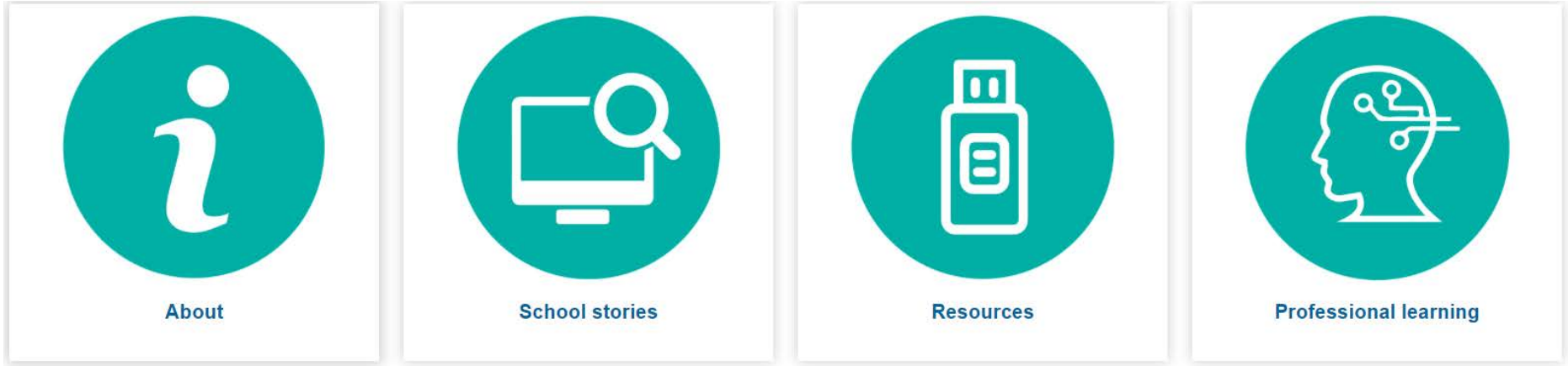
Activity: What's next?

Identify the next steps for planning a STEM Connections unit when you return to school.

- Identify three to five actions for when you return to school to progress implementation of a STEM Connections unit.

RESOURCES

https://www.australiancurriculum.edu.au/resources/digital-technologies-in-focus/



89% of schools find DTiF plugged and unplugged resources useful

www.australiancurriculum.edu.au/resources/digital-technologies-in-focus/resources/

Contact

Julie King

Senior Manager, Curriculum

ACARA

julie.king@acara.edu.au

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