STEAM into STEM:
Linking to the Australian Curriculum

Overview

1. What is STEM education?
2. School context
3. Why the focus on STEM education?
4. Beginning the STEM Curriculum Journey?
5. STEAM to STEM Curriculum?
6. Implementing STEM curriculum - Challenges and Opportunities
7. Where to from here?

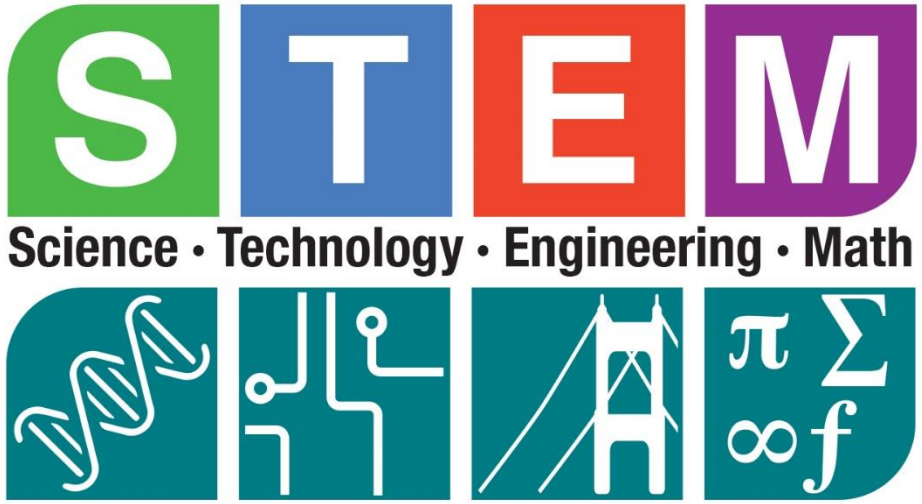
What is STEM Education:

from an analysis of many documents, reports and research articles

STEM - Science, Technology, Engineering, Mathematics

- Separated S.T.E.M. - Each subject is taught separately with the hope that the synthesis of disciplinary knowledge will be applied – referred to as “Silos”

- Integrated STEM - The principles of science and the analysis of mathematics are combined with the design process of technology and engineering in the classroom.



What is STEM?

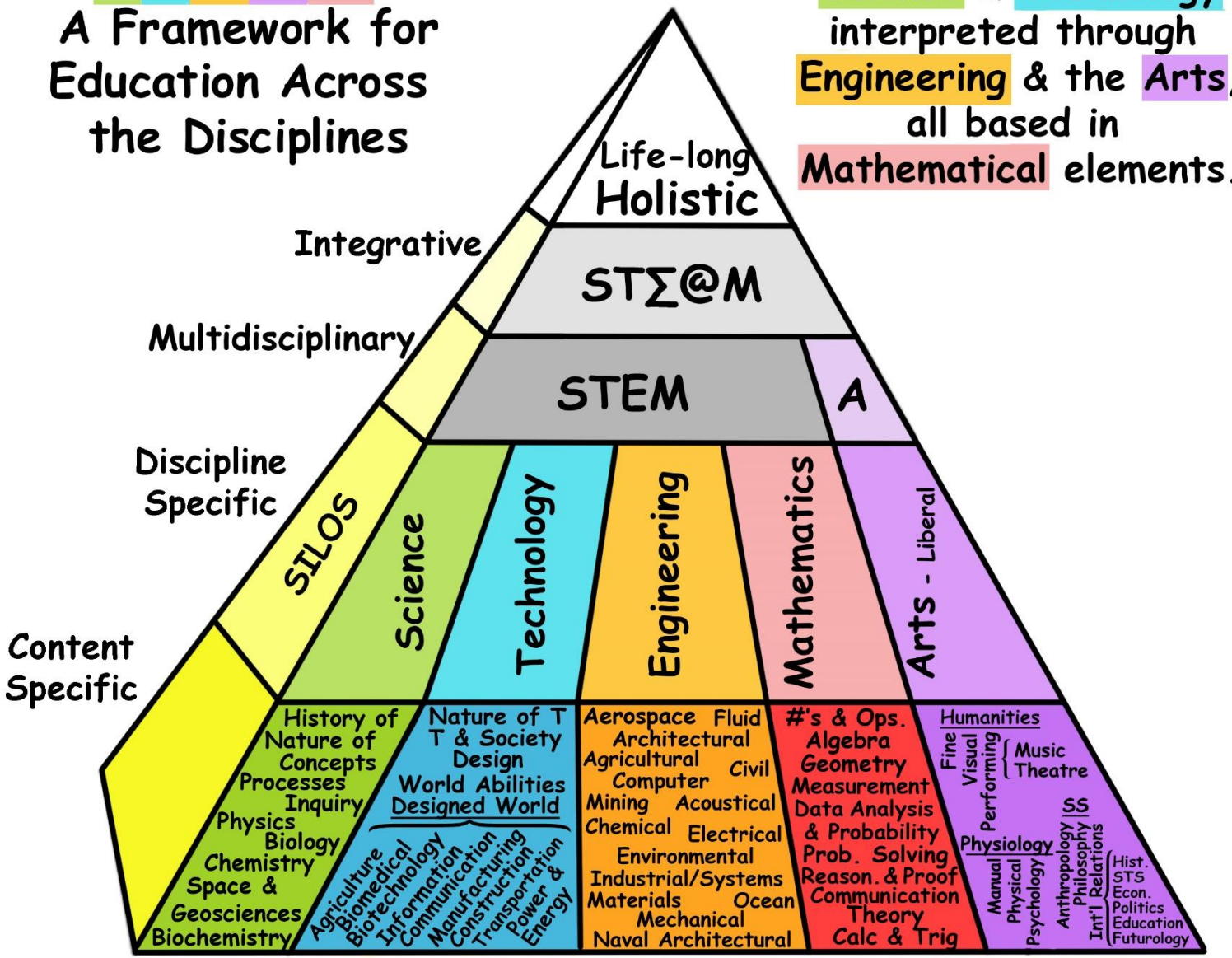
A frequently cited definition of STEM was provided by Tsupros, Kohler, and Hallinen (2009):

> *"STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy."*

So what is STEAM then?

STΣ@M:
A Framework for Education Across the Disciplines

STΣ@M = **Science** & **Technology** interpreted through **Engineering** & the **Arts**, all based in **Mathematical** elements.



www.STEAMedu.com

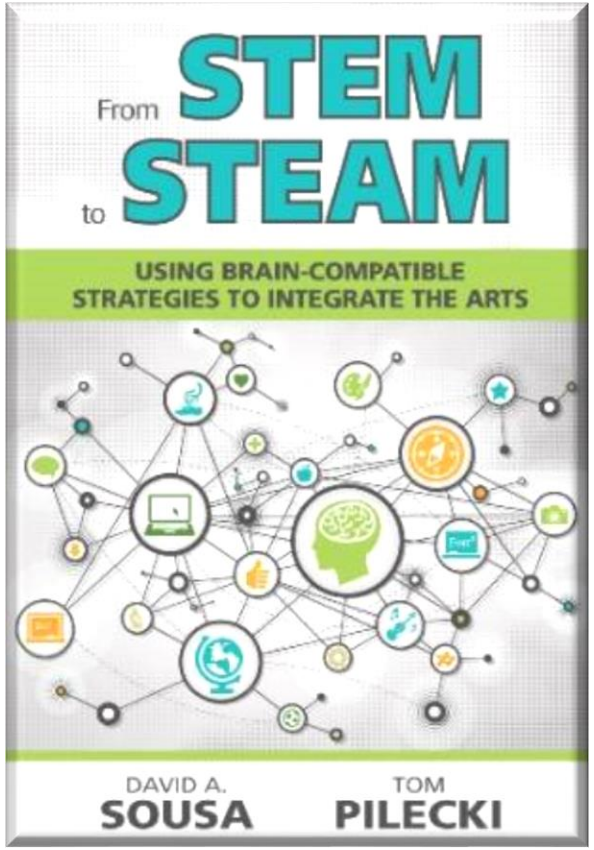
art is education

every child, every school, every day

- **Language arts** (English, ESL,…)
- **Fine arts** (painting, sculpture…)
- **Physical arts** (sports, dance…)
- **Manual arts** (physical skills…)
- **Liberal arts** (sociology, philosophy, psychology, history, …)

Arts education

- Art
- Drama/Theatre
- Music
- Dance
- Film
- Creative Writing
- Architecture/Landscape Design



Corwin/Sage: 2013

Arts education (research)

The arts can be, for both students and teachers, forms of expression, communication, creativity, imagination, observation, perception, and thought…The arts can also open pathways toward understanding the richness of peoples and cultures that inhabit our world, particularly during this period of global change.

(Bucheli, Goldberg & Philips: 1991/2013, *Harvard Educational Review,* Expanding our Vision for the Arts in Education)

Arts education

- **creativity** - innovation, ingenuity, imagination
- **aesthetics** – beauty, sentiment, contemplation
- **ethics** – virtues, human rights, justice
- **rhetoric** – expression, representation, persuasion

‘higher-order’ abilities

STEAM Education - WA

‘The Crazy Scientist’ - *Gary Cass*
bioalloys + fashion design

‘The Beer Dress’
bacterial fermentation of beer…microbial cellulose technology

- World Expo Milan, 2015
- National Science Week Perth, 2015
- artist in residence @ CA SHS, 2016
- Art + Technology + English

bioalloy.org

Governing Curriculum Authorities

Queensland Government
Education Queensland

Education Queensland STEM Statement

The state schools approach to STEM education maintains the integrity of individual learning areas aligned to the Australian Curriculum, and supports interdisciplinary approaches to real-world contexts.

Everton Park State High School

- Small School (250) students
- Years 7 – 12
- Brisbane city (8km North of CBD)
- Transitional suburb (ex-low SES suburb)
- https://evertonparkshs.eq.edu.au/Pages/default.aspx

Where every student is known

Everton Park State High School spared the State Government axe

SHANNON SAGAIDAK QUEST NEWSPAPERS SEPTEMBER 17, 2013 3:35PM

SHARE 0 COMMENTS SAVE THIS STORY

Everton Park High School students Joel Bennet, Kayla Brock, Priscilla Iles, Ebony Bain Perkins, Thida Hamtun,

Why STEM in the beginning? (2013)

- Gap in local market
- Sports schools/Arts schools/Schools of excellence (capped)
- Message from admin – ‘No such thing as business as usual’
- STEM was seen to be a marketing tool for the school
- STEM was introduced as an Elective class in year 9&10 (3x70min)

Why STEM HODS perspective?

- New HOD appointed in 2014
- Implementation of C2C
  - Prescriptive
  - Baby thrown out with the bath water
- Opportunities to bring back project based learning
- Inquiry learning opportunity (time)

Why STEAM?

In 2015 the following were identified;

- Teacher capability issues
  - Knowledge of curriculum
  - Willingness to teach curriculum
- Time table issues
  - How to fit in all electives into offerings?
  - Who to teach electives & when?
- HR
  - Where are the technologies & art teachers coming from?

STEM Curriculum – Beginning the Journey 2013

	Year A	Year B
Term 1	**Robotics** • Introduction to robotics • Flow charting • Programming basics • Basic numeracy • Data gathering • Graphing • Conditional statements	**Green Buildings** • Energy in buildings • Home wind turbines • Home solar electric systems • Energy for heating buildings • Home solar water heating systems • Insulation • Glass in construction • Heat pumps • Air-conditioning • Building a sunroom

Term 2	**Structures** • Forces on structures • Beams • Concrete • Green materials for construction • Problem solving: Building bridges	**Intro to electronics** • Electric Current • Voltage • Resistance • Relationship between Voltage, Current and Resistance • Switches • Safety and Protection Devices • Magnetism • Motors • Generators and Transformers • Problem Solving

	Year A	Year B
Term 3	**Pneumatics , hydraulics** • Principles of Pneumatics • Components, Symbols and Circuits • Cylinders • Valves • Speed Control • Pneumatic Logic Functions • Electro-pneumatics • Sequential Control & Automatic Circuits • Time Delays • Problem Solving	**Industrial Control** • Introduction to Industrial Control and Manufacturing • Industrial Controllers • Human Versus Machine • Logic (AND, OR, and NOT) • Truth Tables and Step Logic • Latching Actuators • Counting Parts • Timing Events • Measuring Part Width • Problem Solving – Sorting Parts

Term 4	**Robotics (ext)** • Data logging • Environmental • Biological • Technological • Testing • Date Set • Resolution • Sample Frequency	**Mechanisms** • Mechanical Systems and Motion • Gear Trains • Changing Axis of Rotation with Gears • Belt Drives • Pulleys • Levers • Cams and Cranks • Inclined Planes • Friction • Problem Solving

Curriculum STEAM to STEM

- Importance of the Arts to the STEM philosophy of teaching
- The Arts are imperative to connecting the dots between the disciplines of STEM
- Arts education is a key to igniting creative and imaginative thinking which is an essential driver behind innovation a founding principle behind STEM education
- Teaching and preparing students for jobs that at present do not even exist
- Need to train and educate students on how to interface with technology no matter what digital solution might emerge or to design solutions that have never been considered previously.
- STEM intertwines principles of Science, Technology, Engineering & Mathematics with key skills such as problem solving, strategic thinking and collaboration to produce quality products.

Year 7 STEAM

Term 1	Term 2	Term 3	Term 4
• Principles of design • Elements of design • Sketching • technologies	• Coding – intro scratch etc	• Robotics – intro Sphero? Arduino?	• Rapid prototyping

Year 8 STEAM

Term 1	Term 2	Term 3	Term 4
• Science of flight	• Sustainability – Clean energy / Aquaponics / material science / developing technologies	• Structures – Bridges	• Coding – Make an app

STEAM 7-8 Assessment Rubric (10/02/2016)

Dimension	Strand	Content Descriptors	A
Knowledge and Understanding	Concepts and Procedures	• Investigate how data are transmitted and secured in wired, wireless and mobile networks, and how the specifications of hardware components impact on network activities (ACTDIK023) • Investigate how digital systems represent text, image and audio data in binary (ACTDIK024) • Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions (ACTDEK031) • Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)	Comprehensive description and explanation of the features of technologies and technological processes. Comprehensive description and explanation of how the features of technologies and technological processes influence the creation of technological products, services and environments.
	STEAM and Society	• Examine and prioritise competing factors including social, ethical and sustainability considerations in the development of technologies and designed solutions to meet community needs for preferred futures (ACTDEK029) • Investigate the ways in which products, services and environments evolve locally, regionally and globally through the creativity, innovation and enterprise of individuals and groups (ACTDEK030) • Identify and connect specific features and purposes of designs from contemporary and past times to explore viewpoints and enrich their design, starting with Australian designs including those of Aboriginal and Torres Strait Islander Peoples (ACAVAR124) • Identify specific features and purposes of multi - media designs from contemporary and past times to explore viewpoints and enrich their media design making, starting with Australian media design including of Aboriginal and Torres Strait Islander media designs (ACAMAR072)	Comprehensive description and explanation of: • factors, including social, ethical and sustainability, which influence the design of technological products, services and environments to meet present and future needs. • the changing contributions of technological innovations to society. Identification and thorough analysis of: • how representations of social values and points of view are portrayed in the multimedia made, distributed and viewed. • the social and ethical responsibility of the makers and users of media artworks.

School Time Table

	Monday	Tuesday	Wednesday	Thursday	Friday
Home	8:55-9:05 08-2 MCKEME H07	8:55-9:05 08-2 MCKEME H07	8:55-9:05 08-2 MCKEME H07	8:55-9:05 08-2 MCKEME H07	8:55-9:05 08-2 MCKEME H07
Per 1	9:05-10:15 HPE082B WYNNST H06	9:05-10:15 SCI082B LYNCMI K02	9:05-10:15 MAT082B STIRPE K04	9:05-10:15 ENG082A WYNNST H06	9:05-10:15 ENG082A WYNNST H06
Per 2	10:15-11:25 STA082B LEWITI B01	10:15-11:25 FDS082B COXCA0 C06	10:15-11:25 SCI082B LYNCMI K02	10:15-11:25 GEG082B MCKEME H07	10:15-11:25 ENG082A WYNNST H06
Per 3	12:05-1:15 FDS082B COXCA0 C06	12:05-1:15 MAT082B STIRPE K04	12:05-1:15 FDS082B COXCA0 C06	12:05-1:15 STA082B LEWITI B01	12:05-1:15 GEG082B MCKEME H07
Per 4	1:50-3:00 MAT082B STIRPE K04	1:50-3:00 ENG082A WYNNST H06	1:50-3:00 SPT072B MCKEME	1:50-3:00 MAT082B STIRPE K04	1:50-3:00 STA082B LEWITI B01

What is Step Up?

www.stepup.edu.au

- StepUp is one of the five ETMST projects that aims to bring together Science, Maths and Education experts from universities across Queensland, with schools, government agencies and industry bodies, to develop a shared framework and initiatives that benefit maths and science teacher education across the state.

QUT Queensland University of Technology

StepUp

Australian Government

Office for Learning & Teaching

What is the STEM Studio?

- The STEM Studio provides a unique third space that brings together key participants from higher education (teacher educators, scientists and pre-service teachers) and high schools (Principals, practising teachers and school students).
- In essence:
  - 1-2 PSTs, an IST, Teacher-Educator, Discipline Expert
  - Plan and teach 4 lessons in a school classroom over a 4 week period
  - Non-assessed, extra-curricular ‘third space’

STEM Educator in Residence

- Funded in school 1 day / week
- Facilitate STEM Studio as well as broader university-school partnership

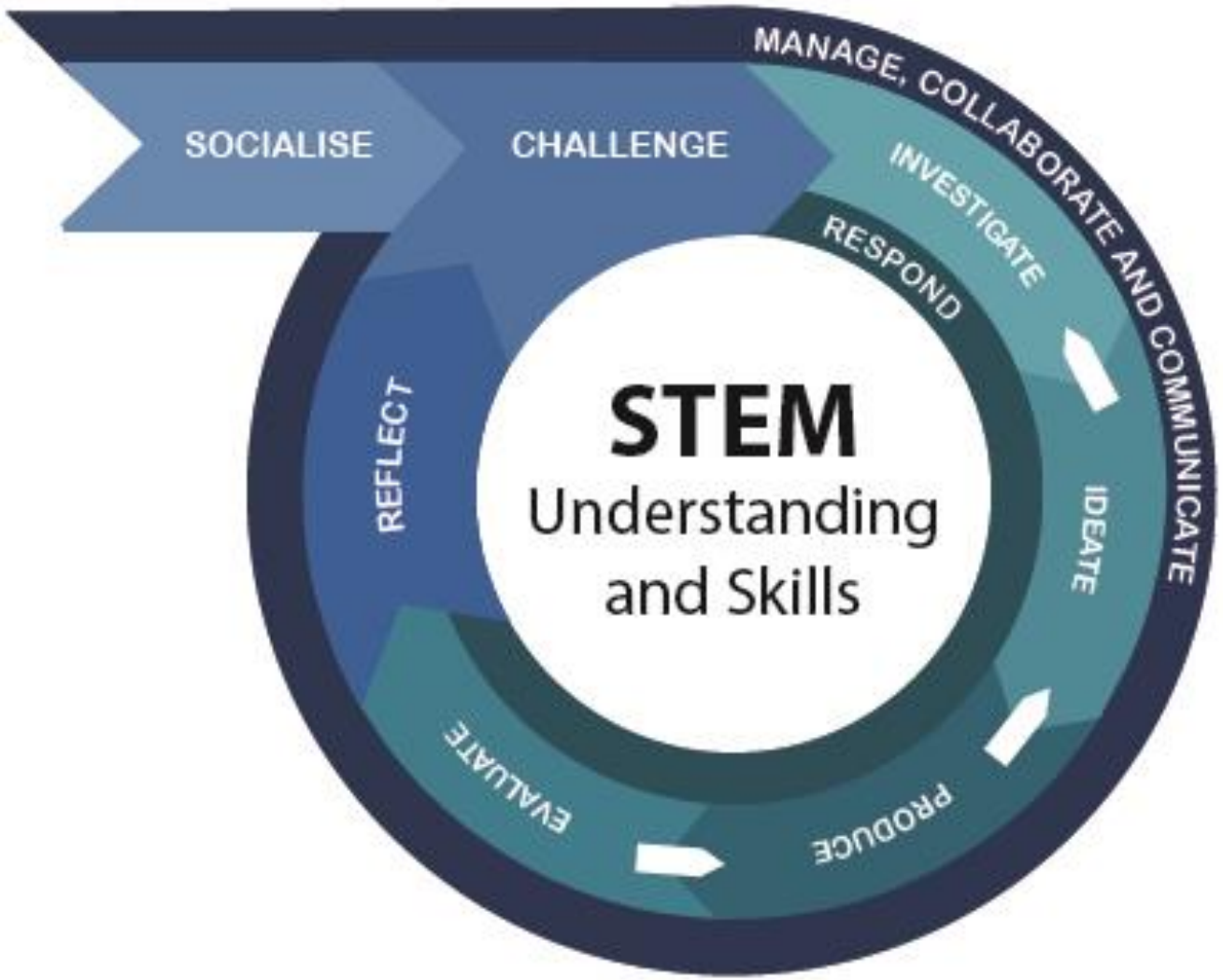
The whole process of education should thus be conceived as the process of learning to think through the solution of real problems

John Dewey, 1938

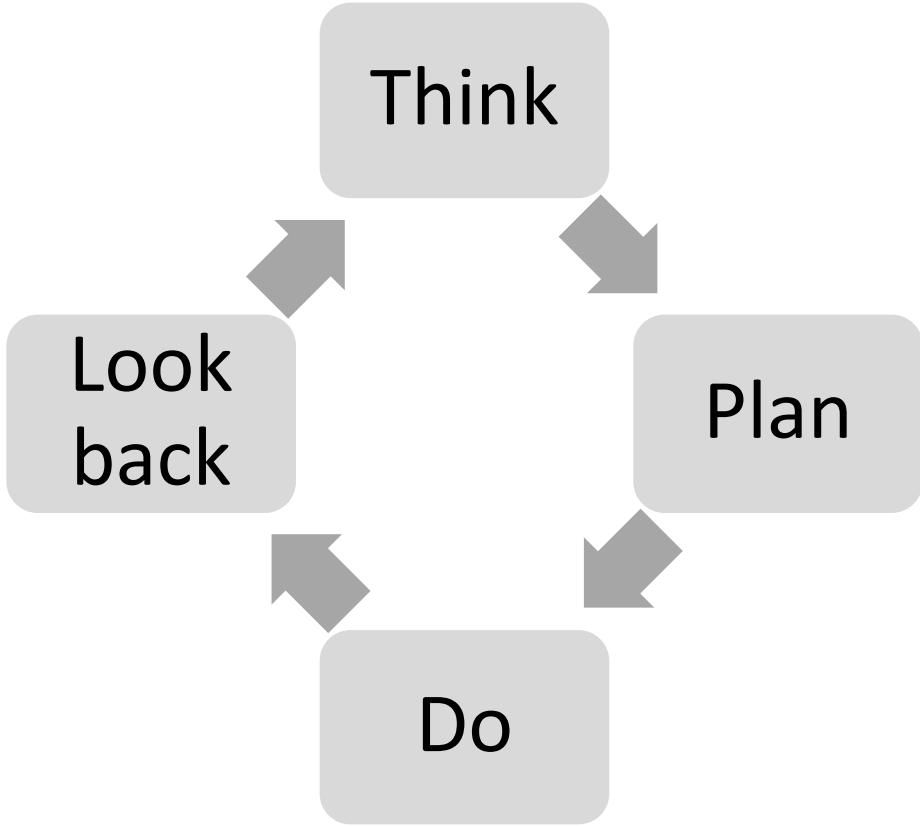
STEM-IP model

- After first year, sat down with ISTs, TE and Engineering DE to talk through various experiences, models and curriculum documents.
- Emergence of STEM-Inquiry Process as a basis for guiding teachers (pedagogical model) and students (engineering process) as they engage in learning based upon problems or design challenges.

STEM-IP Model



Polya's Problem Solving



STEM Problem Solving Pedagogies (1)

<table>
<tr><th>Polya's Principles</th><th>Mathematical Modelling</th><th colspan="3">Model Eliciting</th></tr>
<tr><td>1. Understand the problem</td><td rowspan="2">1. Mathematise</td><td colspan="3">1. Warmup</td></tr>
<tr><td>2. Devise a plan</td><td rowspan="3">2a. Model Eliciting</td><td rowspan="3">3a. Model exploration</td><td rowspan="3">4a. Model Adaptation</td></tr>
<tr><td>3. Carry out the plan</td><td rowspan="2">2. Manipulate</td></tr>
<tr><td>4. Look back on your work</td><td>3. Interpret</td><td>2b. Discuss</td><td>3b. Discuss</td><td>4b. Discuss</td></tr>
</table>

STEM Problem Solving Pedagogies (2)

<table>
<tr><th>Polya's Principles</th><th colspan="2">Science Inquiry (5Es)</th><th>Working Technologically</th><th colspan="2">LEGO 4Cs</th></tr>
<tr><td rowspan="2">1. Understand the problem</td><td colspan="2">1. Engage</td><td rowspan="2">1. Investigation</td><td colspan="2">1. Connect</td></tr>
<tr><td rowspan="3">2. Explore</td><td rowspan="3">4. Elaborate</td><td rowspan="3">2. Construct</td><td rowspan="4">4. Continue</td></tr>
<tr><td>2. Devise a plan</td><td>2. Ideation</td></tr>
<tr><td>3. Carry out the plan</td><td>3. Production</td></tr>
<tr><td>4. Look back on your work</td><td>3. Explain</td><td>5. Evaluate</td><td>4. Evaluation</td><td>3. Contemplate</td></tr>
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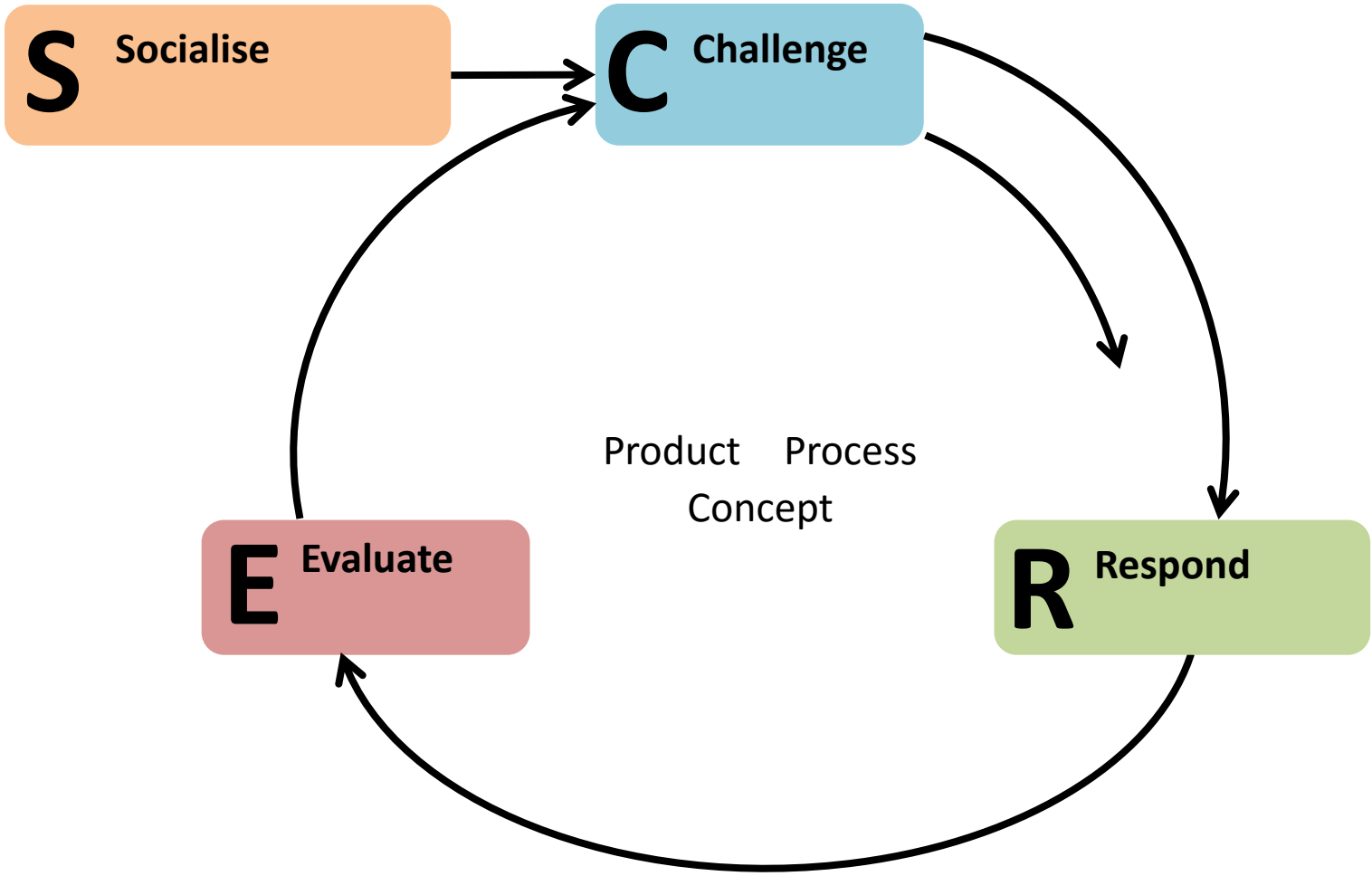
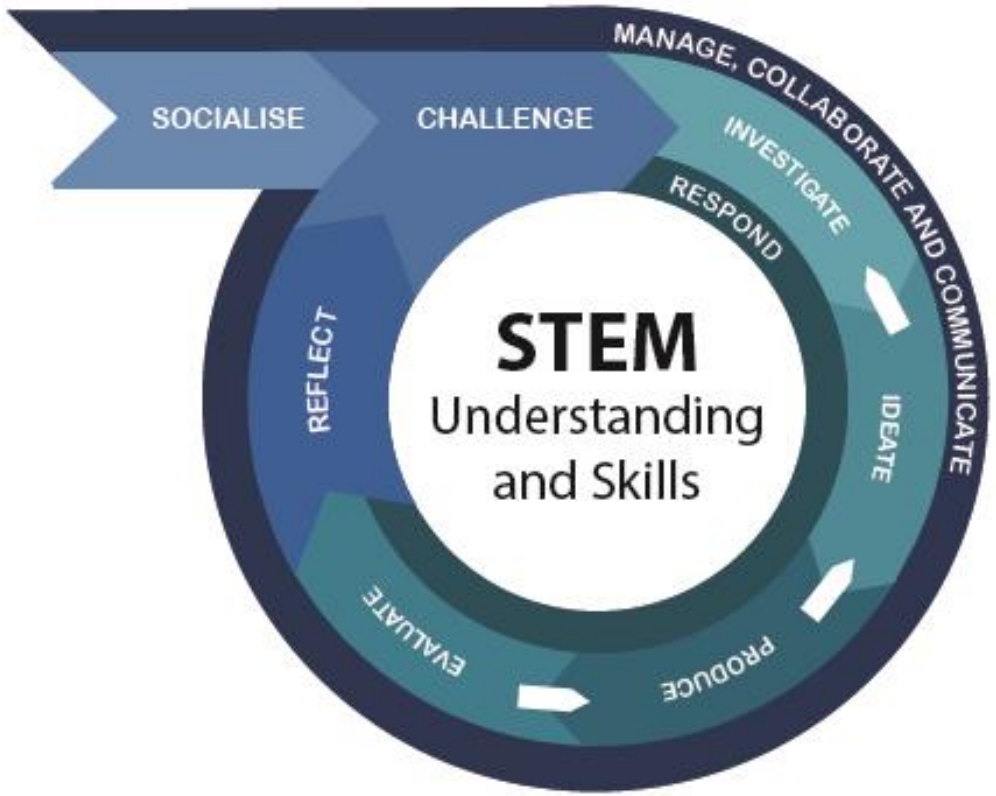
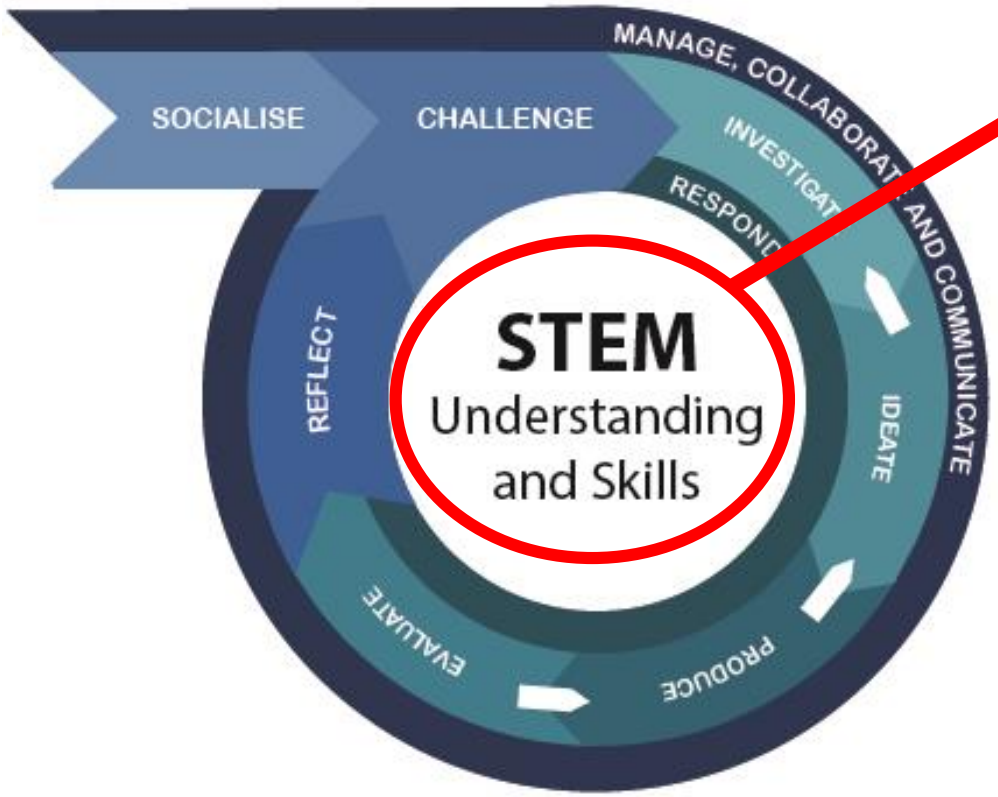
S-CRE Model


S
Socialise
C
Challenge
Product
Process
Concept
E
Evaluate
R
Respond



- The model is cyclical – a sequence of several related problem solving activities.
- Problems may get increasingly complex and/or students get less support.

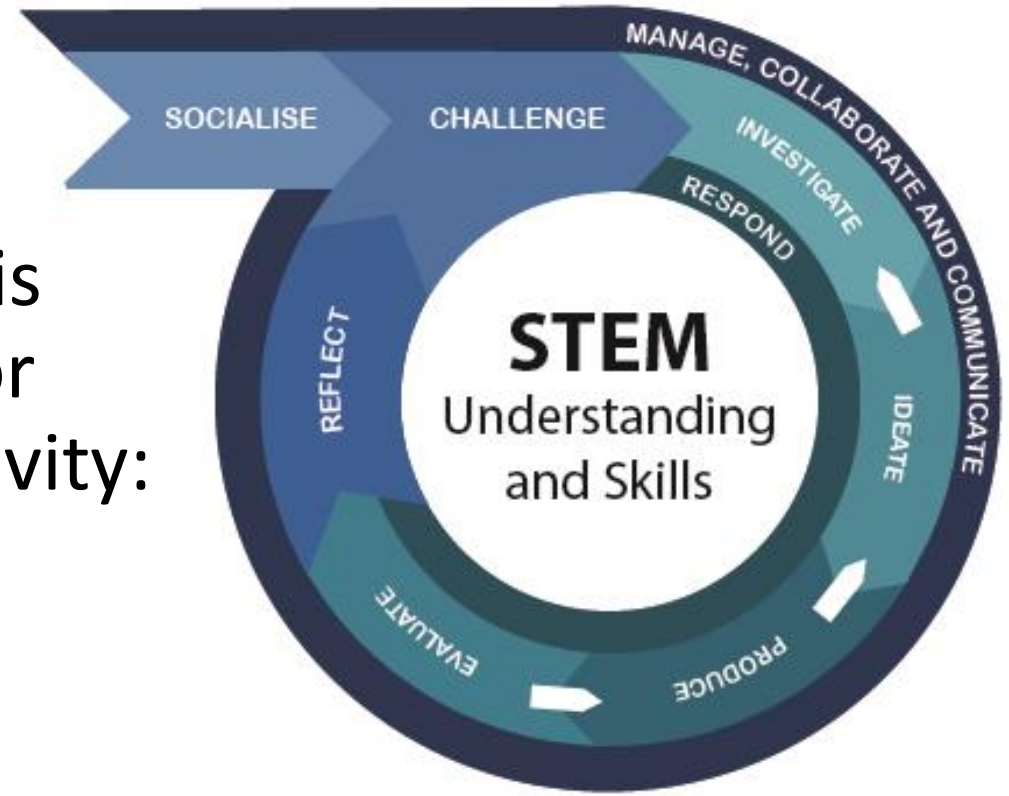


Central to the STEM-IP model are:

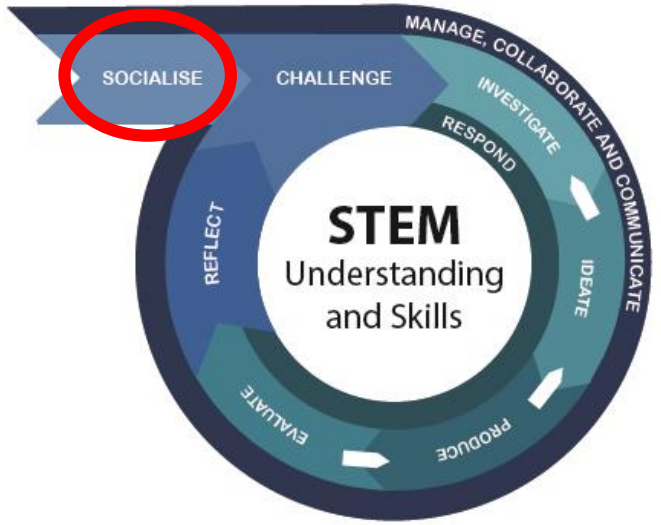
- **Understanding** – the facts, processes and concepts of STEM disciplines
- **Skills** –the ways of working in the STEM disciplines

The STEM-IP model is comprised of 4 major types of student activity:

1. Socialise
2. Challenge
3. Respond
4. Reflect



Socialise

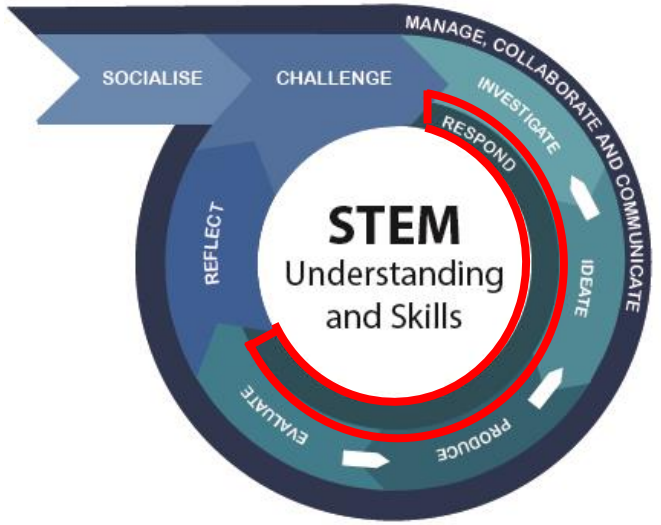


- Introduce students to the context
- Promote curiosity, student questions and to elicit students' prior knowledge.
- Establish base knowledge needed to make sense of the problem to be posed.

Challenge

- Problem is posed for the students to address.

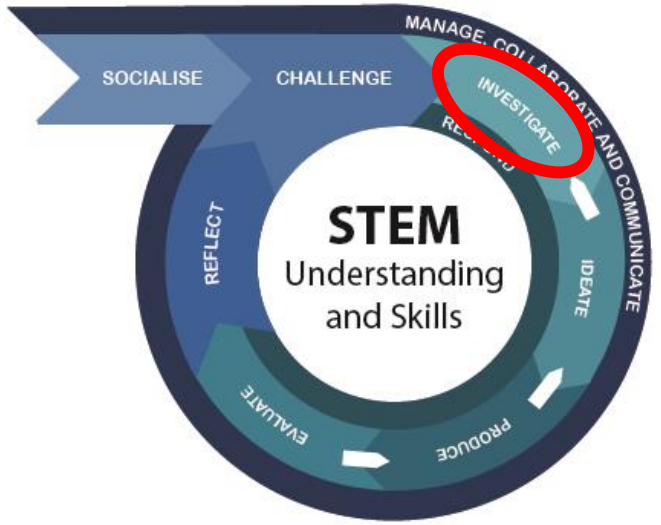
Respond



- Solve the problem that has been posed.
- 4 sub-phases.
- Based upon Polya's process

1. Think → Investigate
2. Plan → Ideate
3. Do → Produce
4. Look back → Evaluate

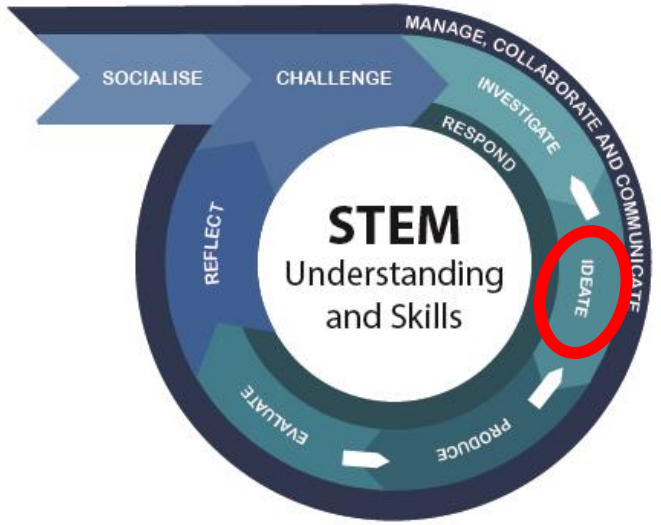
Investigate



Students understand the problem by:

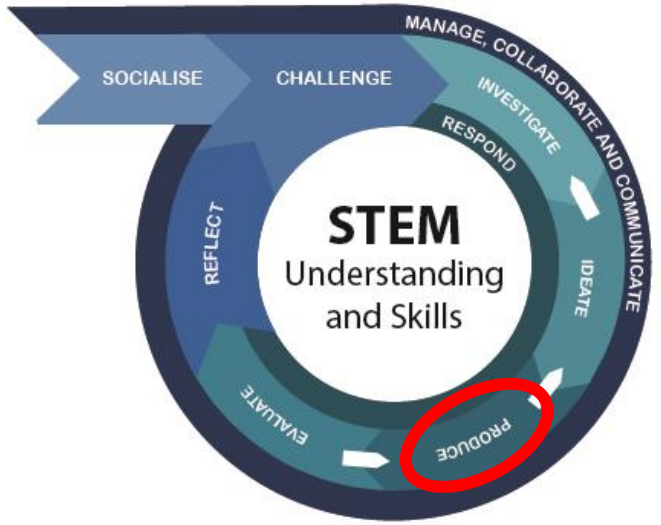
- Asking questions
- Break problem into parts
- Researching

Ideate



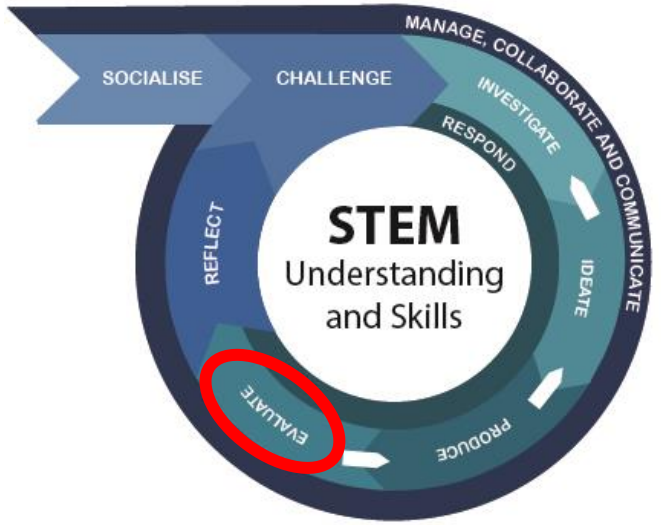
- Generating, designing, evaluating and communicating alternative solution ideas
- Plan how they will work.

Produce

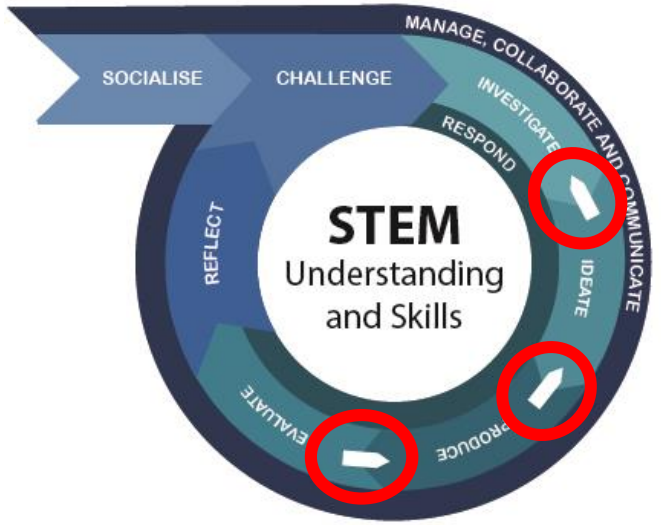


- Refine the solution’s design
- Implement the solution
- Learn new ideas and processes as needed

Evaluate

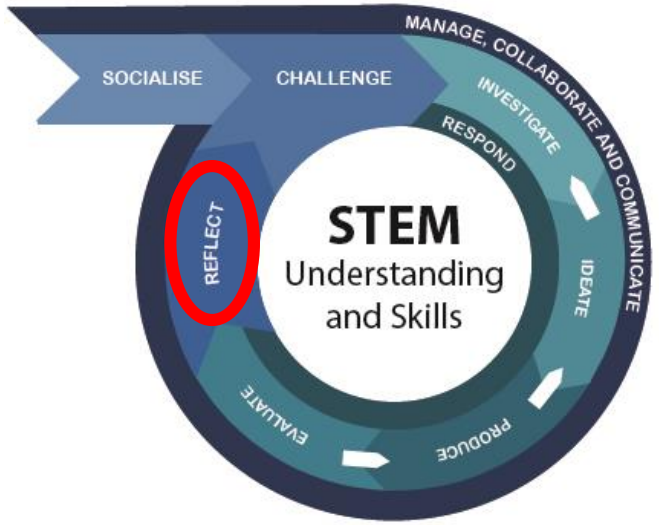


- Test the solution.
- Compare solution to problem specification
- Justify their findings / result
- Present and compare solutions.



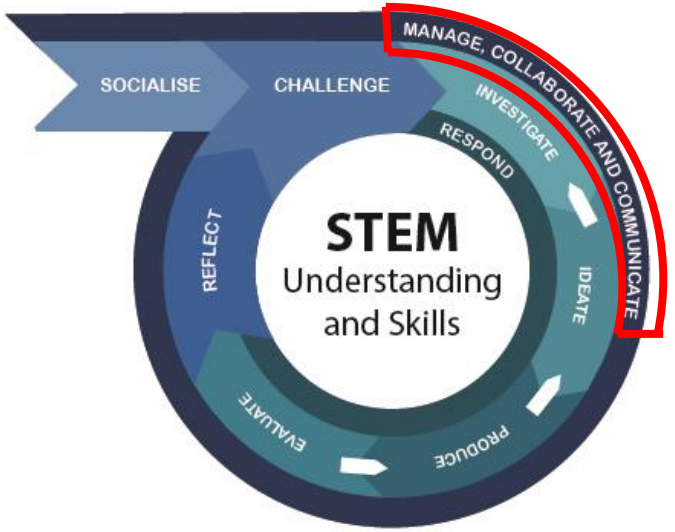
- Sometimes, problem solving does not go to plan
  - Perhaps the tests fail → re-make solution
  - Perhaps solution is not possible → re-design the solution
  - Perhaps design is wrong → re-think the problem

Reflect



- Considering what they have learnt
  - New understanding or knowledge
  - New skills

Manage, Collaborate and Communicate



- Throughout the process
  - Work collaboratively within groups and between groups
  - Manage time and other resources
  - Communicate ideas with peers and share solutions

In short

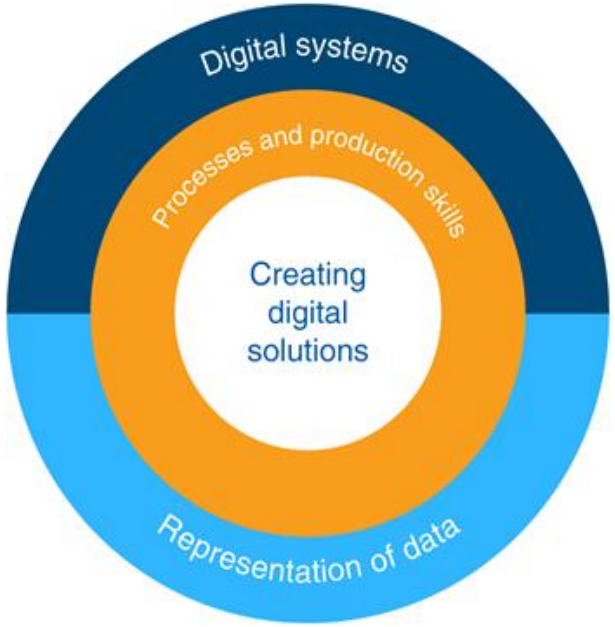
1. Choose a theme or context, introduce the students to it, discover what they already know
2. Pose a problem that requires the students to produce a solution
3. Support students as they design, build and test their solution
4. Help students to reflect upon their experience and identify what they have learnt

STEAM into STEM curriculum

The content of STEAM into STEM has been developed by considering:

- The content descriptors of Australian Curriculum: Technologies and Australian Curriculum : The Arts (Visual Arts and Media Arts)
- The Achievement Standards of the Australian Curriculum documents
- The Standard Elaborations provided by the QCAA for Digital Technologies, Design and Technologies, Visual Arts and Media Arts
- The structure of the STEM-IP model

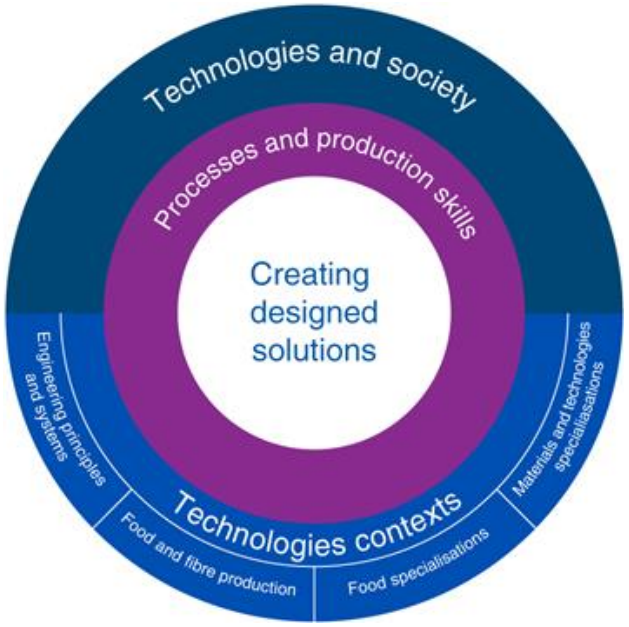
Digital Technologies



Knowledge and Understanding	Process and Production Skills

• Digital Systems
• Representation of Data
	• Collecting, managing and analysing data
	• Creating digital solutions by:
	  ○ Investigating and Defining
	  ○ Generating and Designing
	  ○ Producing and Implementing
	  ○ Evaluating
	  ○ Collaborating and Managing

Design and Technology



Knowledge and Understanding	Process and Production Skills

• Technologies and Society
• Technologies contexts
  ○ Engineering principles and systems
  ○ Food and fibre production
  ○ Food specialisation
  ○ Materials and Technologies specialisations
	• Creating designed solutions by:
	  ○ Investigating and Defining
	  ○ Generating and Designing
	  ○ Producing and Implementing
	  ○ Evaluating
	  ○ Collaborating and Managing

The Arts – Overarching Content Descriptors

1	Exploring ideas and improvising with ways to represent ideas
2	Manipulating and applying the elements/concepts with intent
3	Developing and refining understanding of skills and techniques
4	Structuring and organising ideas into form
5	Sharing artworks through performance, presentation or display
6	Analysing and reflecting upon intentions
7	Examining and connecting artworks in context

Year 7-8 STEAM Knowledge and Understanding

Criteria	Sub-criteria	C-standard
Concepts and Procedures	Technology concepts	Description and explanation of the features of technologies and technological processes.
	Combining and creating technologies	Description and explanation of how the features of technologies and technological processes influence the creation of technological products, services and environments.
STEAM and Society	Preferred Futures	Description and explanation of the changing contributions of technological innovations to society.
	Influencing Factors	Description and explanation of factors, including social, ethical and sustainability, which influence the design of technological products, services and environments.

Year 7-8 STEAM Process and Production Skills (1)

Criteria	**Sub-criteria**	**C-standard**
Collecting, Analysing and Managing Data	Data management	Analysis and evaluation of data from a range of sources.
	Modelling with data	Use of data to create technological solution(s).
Investigating	Problem definition and decomposition	Decomposition and definition of problems by taking into consideration • Needs or opportunities; • Functional requirements; • Constraints.
	Success criteria	Development of criteria for success.

Year 7-8 STEAM Process and Production Skills (2)

Criteria	Sub-criteria	C-standard
Ideating	Solution design	Proposition, creation and comparison of designs for technological solutions.
	Values representation	Representation of social values and points of view in designed works for particular audiences and contexts.
Producing	Solution implementation	Production processes that demonstrate: • use of genre and media conventions and shaping of technical and symbolic elements for specific purposes and meaning; • controlled use of equipment, technologies and technological processes to create solutions and/or achieve intentions.
	Testing and refining	Testing and improvement of technological processes and solutions.
	Safe working	Consideration and following of safe working procedures.

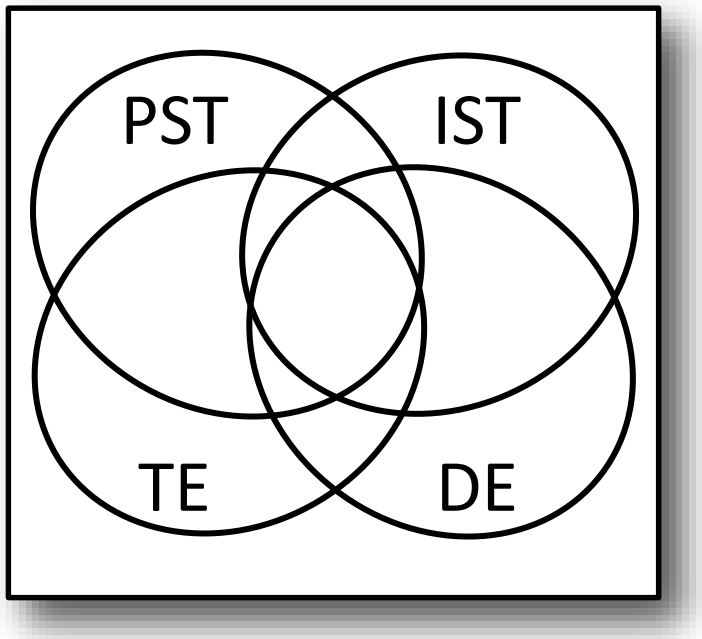
Year 7-8 STEAM Process and Production Skills (3)

Criteria	Sub-criteria	C-standard
Evaluating	Solution and process evaluation	Evaluation of technological solution(s) and processes against criteria for success.
	Critical representation	Evaluation of how designers (including themselves and designers from different cultures, times and places) use elements and principles of design to create designed works that meet functional and non-functional requirements.
Managing, Collaborating and Communicating	Project planning and management	Application of project management skills to document and follow project plans.
	Cooperating and collaborating	Working individually and in groups to complete tasks.
	Communication	Communication of technological ideas, processes, plans or products using suitable technical language and representations.

STEAM into STEM Work Program

Term 1	Term 2	Term 3	Term 4
Year 7			
Elements and Principles of Design	Science of Flight	Gamemaking with Scratch	Robots and Mechanisms
Year 8			
Food production, sound and video production	App building	3D design and printing	Un-manned vehicles
Year 9			
Eco-housing Design	Building automation	Bio-fuel production and fuel-efficient vehicles	Internet of things
Year 10			
Data-driven web design	Cause and effects	Electronics	Bionics

Third spaces in STEM Initial Teacher Education



- "… shifting the epistemology of preservice teacher preparation from a place where academic knowledge in the university is seen as the primary source of knowledge about teaching to a situation where academic knowledge and expert P-12 teachers are treated with equal respect." (Zeichner, 2010, p.93)