Leading STEM Education in Your School

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Overview

• The What and Why of STEM Education
• Developing purpose, polices, programs and practices for STEM
• Analysing your current context
• Developing an action plan
• Identifying the challenges
• Leading change
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.

But there are many other interpretations …
STEM education appears to be synonymous with ...

- Project-based learning
- Problem-based learning
- Solving complex problems
- Real world or authentic problem solving
- Engaged learning
- Inquiry learning
- STEM + Creativity = STEAM??
- Integrated curriculum

STEM – a meta-discipline
STEM curriculum – Content and Discipline focus

Science  
Technology  
Engineering  
Mathematics
<table>
<thead>
<tr>
<th>Science</th>
<th>Technology (Design Technologies and Digital Technologies)</th>
<th>Mathematics (Proficiencies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science understanding</td>
<td>Creating preferred futures</td>
<td>Understanding</td>
</tr>
<tr>
<td>Science as a human endeavour</td>
<td>Project management</td>
<td>Fluency</td>
</tr>
<tr>
<td>Science inquiry skills:</td>
<td>Systems thinking</td>
<td>Problem solving</td>
</tr>
<tr>
<td>• Questioning and predicting</td>
<td>Design thinking</td>
<td>Reasoning</td>
</tr>
<tr>
<td>• Planning and conducting</td>
<td>Computational thinking</td>
<td>Communicating (NSW)</td>
</tr>
<tr>
<td>• Processing and analysing data and information</td>
<td></td>
<td></td>
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<tr>
<td>• Evaluating</td>
<td></td>
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<tr>
<td>• Communicating</td>
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</tbody>
</table>
What constitutes integrated STEM?

How are the subjects similar/different?
## Australian Curriculum K-10

(ACARA, 2010)

<table>
<thead>
<tr>
<th>General Capabilities</th>
<th>Cross-curriculum Priorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literacy</td>
<td>Aboriginal and Torres Strait Islander Histories and cultures</td>
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<tr>
<td>Numeracy</td>
<td>Asia and Australia’s engagement with Asia</td>
</tr>
<tr>
<td>ICT Capability</td>
<td>Sustainability</td>
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<tr>
<td>Critical and Creative Thinking</td>
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<tr>
<td>Personal and Social Capability</td>
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<tr>
<td>Ethical Understanding</td>
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<tr>
<td>Intercultural Understanding</td>
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Goal 1: Ensure all students finish school with strong foundational knowledge in STEM and related skills

Goal 2: Ensure that students are inspired to take on more challenging STEM subjects
Five Areas for National Action  (National STEM Strategy)

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

Separate and Integrated Subjects

Curriculum AND Pedagogy
STEM Education seems to be the answer – What was the question? (Bybee, 2013, p. 41)
If we want students to learn how to apply knowledge, their education experiences must involve them in both learning the knowledge of STEM disciplines and reacting to situations that require them to apply that knowledge in contexts appropriate to their age and stage of development (Bybee, 2013, p. x)
STEM Education in Schools – the PURPOSE

STEM Education

- Policies
- Programs
- Practices

School Context
Student Needs
Analysing the Current School STEM Context
(for each of the disciplines)

• Curriculum:

• Instructional strategies:

• Student achievement:

• Strengths:  Use data!

• Weaknesses:

• Plans:

• Other Comments:
Developing an Action Plan: Moving beyond STEM 1.0

1. Where is your school located on a continuum of integration?
2. Maintain and improve the traditional STEM disciplines
3. Within the STEM disciplines, find places to coordinate, complement, correlate and connect the disciplines
4. Begin where it is easiest, e.g., middle years
5. Develop integrated units of work that can be used within the current curriculum
The inclined plane of STEM integration

(Vasquez, 2014)

**Disciplinary**
- Students learn concepts and skills separately in each discipline

**Multidisciplinary**
- Students learn concepts and skills separately in each discipline but in reference to a common theme

**Interdisciplinary**
- Students learn concepts and skills from two or more disciplines that are tightly linked so as to deepen knowledge and skills

**Transdisciplinary**
- By undertaking real world problems or projects, students apply knowledge and skills from two or more disciplines and help to shape the learning experience

Curriculum Integrity??
Another representation (Jensenius, 2012):

- Crossdisciplinary: viewing one discipline from the perspective of another.
- Multidisciplinary: people from different disciplines working together, each drawing on their disciplinary knowledge.
- Interdisciplinary: integrating knowledge and methods from different disciplines, using a real synthesis of approaches.
- Transdisciplinary: creating a unity of intellectual frameworks beyond the disciplinary perspectives.
Developing an Action Plan: Moving beyond STEM 1.0

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Suggestions for Beginning to Integrate STEM subjects  
(Bybee, 2013, p. 84)

| **Coordinate** | 2 subjects taught separately are coordinated to synchronize content |
| **Complement** | while teaching content of 1 subject, the content of another is introduced |
| **Correlate** | 2 subjects with similar themes, content or processes are taught so students understand similarities and differences |
| **Connections** | use 1 subject to connect with others |
| **Combine** | combine 2 or more subjects using projects, themes, procedures, or other organizing foci |
## Project Based Learning vs. Problem Based Learning

### Similarities

**Both PBLs:**
- Focus on an open-ended question or task
- Provide authentic applications of content and skills
- Build 21st century success skills
- Emphasize student independence and inquiry
- Are longer and more multifaceted than traditional lessons or assignments

### Differences

<table>
<thead>
<tr>
<th>Project Based Learning</th>
<th>Problem Based Learning</th>
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<tbody>
<tr>
<td>Often multi-subject</td>
<td>More often single-subject, but can be multi-subject</td>
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<td>May be lengthy (weeks or months)</td>
<td>Tend to be shorter, but can be lengthy</td>
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<td>Follows general, variously-named steps</td>
<td>Classically follows specific, traditionally prescribed steps</td>
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<tr>
<td>Includes the creation of a product or performance</td>
<td>The “product” may be tangible OR a proposed solution, expressed in writing or in a presentation</td>
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<tr>
<td>May use scenarios but often involves real-world, fully authentic tasks and settings</td>
<td>Often uses case studies or fictitious scenarios as “ill-structured problems”</td>
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### STEM 2.0 (examples?)

<table>
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<tr>
<th>STEM disciplines</th>
<th>Coordinated</th>
<th>Complemented</th>
<th>Correlated</th>
<th>Connected</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science &amp; Technology</td>
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<tr>
<td>Science &amp; Engineering</td>
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<tr>
<td>Science &amp; Maths</td>
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For discussion:

1. What are the advantages and disadvantages of maintaining but improving separate STEM programs?

2. What are the reasons to integrate the STEM disciplines?

3. What are the challenges of integrating, designing and implementing an integrated approach to STEM education?
The Challenges to Integrated STEM Education

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Challenges

• Understanding curriculum requirements across the STEM disciplines – horizontal expertise and boundary crossing (Clarke, 2014)

• Identifying discipline content and processes in already prepared tasks (English, 2016)

• Working effectively in multi-disciplinary school teams (Flowers et al., 2000)

• Designing an appropriate STEM strategy based on data and school context (Daggett & Gendron, 2015)

• Building a community of practice (Wenger, 1998)
Leading Change

1. Why do you want to add STEM to the curriculum? (PURPOSE)

2. What problem are you aiming to solve? (PURPOSE)

Shared Vision
Leading change ...

3. Given the problem, which STEM strategy might address this? (POLICIES/PROGRAMS)

4. Which teachers should be involved (build a team to lead change)? How will you support them? Do they require additional professional learning?

5. What school structures need to change to implement the strategy?

6. How can you find the time and space to develop the plan?

**Collaborative Problem Solving**
Features of effective professional development programs (Desimone, 2010)

• **Content focus**: Professional development activities should focus on subject matter content and how students learn that content.

• **Active learning**: Teachers should have opportunities to get involved, such as observing and receiving feedback, analyzing student work, or making presentations, as opposed to passively sitting through lectures.

• **Coherence**: What teachers learn in any professional development activity should be consistent with other professional development, with their knowledge and beliefs, and with school and state policies.

• **Duration**: Professional development activities should be spread over a semester and should include 20 hours or more of contact time.

• **Collective participation**: Groups of teachers from the same grade, subject, or school should participate in professional development activities together to build an interactive learning community.
Leading change ...

7. What PRACTICES will you implement?

8. How will you know the STEM approach has been effective? (develop your criteria for success)

9. Can you identify parents, industries and/or businesses in the local community to develop partnerships to access resources and support, or to provide an authentic context to the project or STEM unit of work?
Criteria for success of your STEM approach
(for example)

• STEM connections are authentic and meaningful for the cohort of students
• The integrity of subjects is maintained
• The unit of work reflects the curriculum content and intent
• The student activities enhance transfer
• The assessment tasks reflect aspects of the required curriculum standards
• The action research benefits teachers and the schools
Types of partnerships

The partnership continuum

- Levels of Engagement Activities
- Awareness
  - Career Fairs
  - Site tours
  - Industry Ambassadors
- Involvement
  - Industry Mentors
  - Curriculum Development & support
  - Prof. Development Workshops
  - Student Sponsorships
  - Guest Speakers
- Support
  - Small Grants
  - Internships
  - Work Experience
- Sponsorship
  - Education Initiative Sponsorship
  - Large Grants
  - Outreach Programs
- Strategic Partner
  - Joint Partnership
  - Longer-term joint projects
  - Whole-school level involvement

* Adapted from University-Industry Demonstration Partnership
Useful websites for further examples:

ACARA STEM Connections Project
https://www.australiancurriculum.edu.au/resources/stem/

NSW Department of Education

NSW Association of Independent Schools
http://www.aisnsw.edu.au/Services/Partnerships_in_Education/STEM/Pages/default.aspx

The University of Sydney STEM Teacher Enrichment Academy
http://sydney.edu.au/stem/academy/
STEM Academy Partner School Approaches have involved ...

1. Embedding more cross-curriculum applications **within regular lessons**

2. Organising **a STEM day** for a year group to engage in a range of STEM related activities and experiences

3. Conducting **cross-disciplinary investigations** in several STEM subject lessons to design solutions to problems

4. Undertaking **an extended investigation** over several weeks to design an artefact

5. **Redesigning the STEM curriculum program** for a whole year group around themes or big ideas
Final Advice

• Conduct an audit of student enrolments in STEM and student destinations – does this suggest a problem?
• Begin with a trial in a few classes and with key teachers
• Bring the parents with you
• Collect data from students/parents
• Consider an industry partner

“The rigidity and resilience of school curriculum structure should not be underestimated when proposing reform …”
(Williams, 2009, p. 27)