Conceptualising and Implementing Interdisciplinary Approaches to STEM Education

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STEM as the solution – not the problem

What is it that a STEM perspective helps us to understand?

The demographics of educational participation are widely recognised. Demographically differentiated participation in STEM reflects more general social reproductive mechanisms operating in society, rather than indicating a problem idiosyncratic to the STEM area.

It is possible to reconstruct STEM as the solution, rather than the problem: STEM-led educational reform. That is, not educational reform as a mechanism for increasing STEM participation, but, instead, STEM participation as leveraging educational reform.

What is it that STEM brings together?

We are so accustomed to the subject grouping for which STEM is the acronym, that it is difficult to recognise that STEM could be the name for a fairly monumental category error.

What is it that **S**cience

Technology

Engineering, and

Mathematics

have in common?

One reasonable answer is "not much"!

What is it that STEM brings together?

One approach is to consider the nature of the truth claims characteristic of each discipline and the authorities to which such truth claims might appeal:

Science – empirical consistency

Technology – tool utility

Engineering – built viability

Mathematics – logical coherence

This approach seems interesting, but also demonstrates just how fundamental are the differences between STEM disciplines.

Constructing Connection

Vocational coherence

Disciplinary permeability

Proposition 1: Interdisciplinarity through Vocational Coherence

Attention must be paid to the affordances of affiliation and research undertaken to explore the legitimacy of STEM disciplines as communities of practice offering **enhanced educational opportunities through their interconnection**.

Communities already exist that employ STEM skills as integral and interconnected components of professional practice: Engineering, Medicine and Architecture. Here **interdisciplinarity is achieved through vocational coherence.**

Proposition 2: Interdisciplinarity through Disciplinary Permeability

One approach is to examine those constructs to which the boundary walls of the STEM disciplines seem most permeable.

Discourse, Artefacts, Reasoning & Evidence

How permeable are the disciplinary boundaries? And to which constructs are they permeable? Here are four contenders:

Discourse – reasonable speech

Artefacts – constructed objects

Reasoning – purposeful thought

Evidence – objects of justification

How are these constructs transformed in their passage between STEM cells? Do we find conservation of form accompanied by transformation of function?

What if such objects became the structural elements of a new curriculum?

An Emphasis on Team-based Practice

The contemporary workplace has become “flatter in structure, more collaborative and service-focused” (Collet & Hine, 2013, p. 2).

“Boundary crossing will be the basic mode of operation in flat, team- and network-based organizations” (Engeström, Engeström, & Kärkkäinen, 1995, p. 321).

Re-conceptualising Teacher Expertise

The STEM disciplines provide the sites for the development of horizontal expertise through an emphasis on cross-disciplinary team-based practice. Team-based teaching offers similar affordances.

Working in such teams, expert teachers become expert boundary crossers. But what do these boundary crossers carry with them?

What are the boundary objects of the STEM disciplines and what are the implications for curricula and teacher expertise?

Discourse, **A**rtefacts, **R**easoning and **E**vidence

Interdisciplinarity and Integrity

Interdisciplinarity is not integration and the evidential bases and signature practices of the constituent STEM disciplines can be quite different, maintaining disciplinary integrity.

Team-based practice and horizontal expertise need not undermine domain-specific expertise. Education for collaborative specialisation requires interconnection across disciplinary boundaries not their demolition.

The practices of any particular STEM profession (e.g., engineers, doctors and architects) have a coherence that derives from the function of that profession, while employing skills drawn from a variety of separate STEM disciplines.

What is the goal of STEM-Education?

Job capable graduates able to draw on STEM-related skill sets and more generic expertise related to communication, adaptability, collaboration, ethical practice, and creative problem solving in a wide variety of workplace settings.

Putting STEM to Work

How does STEM achieve interdisciplinarity?

Interdisciplinarity through vocational coherence

Disciplinary permeability with respect to key constructs:

Discourse

Artefacts

Reasoning

Evidence

What is the goal of STEM-Education?

Job capable graduates with horizontal expertise

STEM could be the vehicle for a new approach to disciplinary connection and the transformation of the organizing principles of the curriculum and of teacher expertise.

Another view to bring STEM together

What is it that **S**cience and

Mathematics

have in common? β

And what about **T**echnology and

Engineering? Techniek

Another view to bring STEM together

What is it that **S**cience and **M**athematics have in common?

Research:

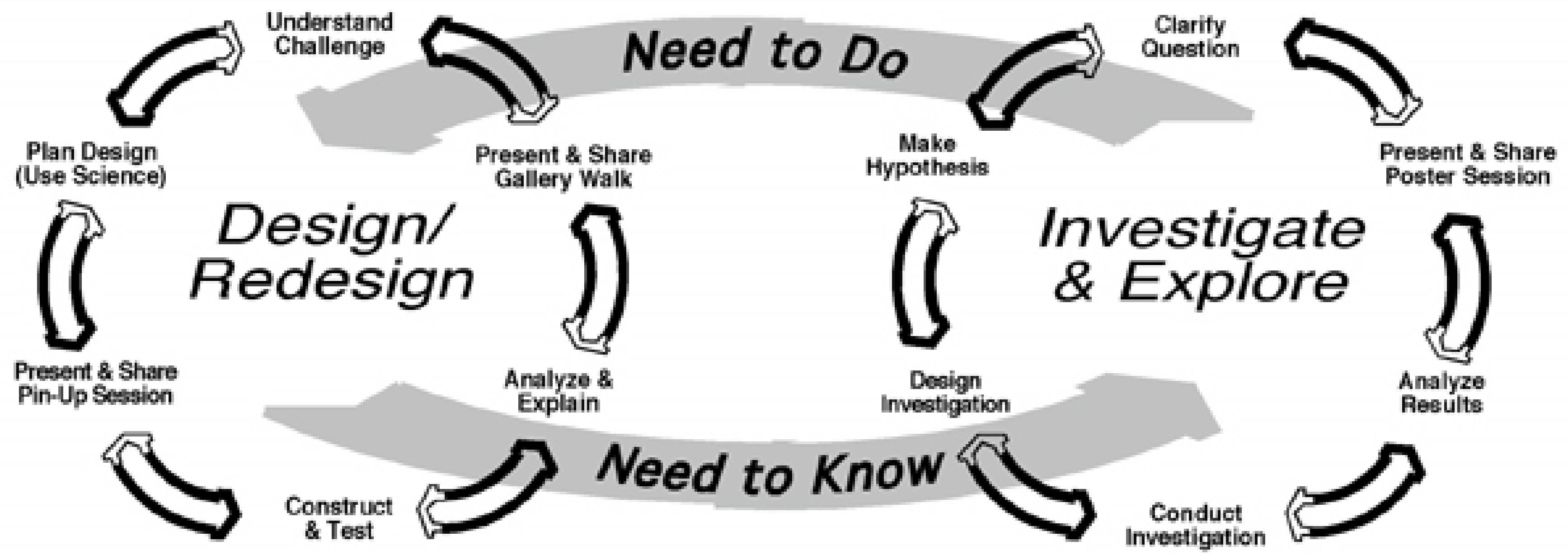
Explaining, **U**nderstanding, **P**redicting

And what about **T**echnology and **E**ngineering?

Design:

Creating, **I**mproving, **O**ptimizing

Research and design as interlinked practices



Kolodner, Gray & Fasse (2003)

Implementing STEM in practice

[Technasium]

A Dutch example of secondary STEM education

Implementing STEM in practice

[Technasium]: A Dutch example (1)

Interdisciplinarity and integrity:

- Introducing Research & Design as a new subject, alongside ‘mono-disciplines’ from Grade 7-12.
- Teaching R&D is organized in multidisciplinary teams
- Authentic ‘real life’ projects

Implementing STEM in practice

[Technasium]: A Dutch example (2)

Crossing boundaries: *Emphasis on practice!*

- R&D projects initiated by parties external to the school
- Students working in project teams
- Teachers focus on supervision: collaborating, feedback
- Schools are connected in regional networks

Implementing STEM in practice

[Technasium]: A Dutch example (3)

Impact:

- Growth from 5 to 93 secondary schools in 10 years
- Sustained relationships between schools, industries and higher education institutes
- Certification program for teachers, recognized by the government

What is the ultimate goal of STEM-Education?

Job capable graduates able to draw on STEM-related skill sets and more generic expertise in a wide variety of settings.

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Job capable graduates able to draw on STEM-related skill sets and more generic expertise in a wide variety of settings.

The challenge for STEM-Education is to create conditions for individuals to engage in well-connected and rich activities throughout their formal education and beyond.

Thank You

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For information about the International Centre for Classroom Research (ICCR):

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