

Putting STEM Education Under the Microscope

October 19, Deakin University - Burwood

Overview

STEM Education has become a major policy priority in Australia and internationally, and there is growing interest in inter-disciplinary curriculum versions of STEM. Policy drivers for this emphasis are various, but their interrelations are not clearly articulated. They include national economic needs, engagement of students, and workplace relevance through STEM-specific and ‘soft’ skill development. Questions are also raised about the coherence of what is practiced in schools under the inter-disciplinary STEM banner, and its relation to existing school subjects, and progressive agendas in disciplinary education.

The STEM education forum provides an opportunity for science and mathematics educators to critically examine current trends in interdisciplinary and disciplinary STEM Education, challenges associated with crossing boundaries between the STEM disciplines, issues of policy and practice, inclusion/exclusion, and opportunities to make STEM a conduit for productive curriculum change.

Featuring input from leading international scholars in STEM Education the forum will be organised to maximise discussion aimed at clarification of a key curriculum issue for Australian STEM Education.

The forum will aim to generate significant insight and commentary on contemporary advocacy of STEM in Australia. It is envisaged that the forum will generate a set of issues and principles that will contribute significantly to the STEM policy and practice debate, from a teacher education perspective.

The forum will be contextualised within current Australian policy rhetoric, pointing to productive possibilities, ambiguities and contradictions in contemporary STEM advocacy. A summary of current STEM policy and practice settings arising from the STEM Education Conference (held in Geelong, October 5-7) will also be presented.

Questions to be addressed

- What are the key drivers of the STEM curriculum agenda?
- What are the productive possibilities opened up for enlivening curriculum in the STEM subjects?
- What are the challenges and opportunities for science and mathematics subject disciplines?
- What can we learn from the history of advocacy for curriculum integration?

Featured Speakers

The featured speakers will provide provocations for substantial discussion within the forum:

- Professor Julian Williams, University of Manchester
- Professor Richard Lehrer, Vanderbilt University
- Professor Peter Fensham, Monash University
- Professor Günter Törner, Universität Duisberg-Essen

Introduction – Professor Russell Tytler & Dr Linda Hobbs

Russell Tytler

- Push for STEM and rapid rise in focus on STEM and is an organising acronym for a whole field of endeavour.
- Captured people's imagination, particularly in regard to policy.
- Discourse is around national interests.
- Jobs with STEM capabilities drive the economy and personal productivity.
- Economic argument.
- General call for change in way see capabilities of students and the need for students to be flexible and to participate in workplace that involves digital futures and creativity.
- STEM is not the only game in town, for need to also acknowledge arts etc.
- Constant shifting in the meaning of STEM.
- Integrated and coherent set of skills and capabilities (in relation to curriculum).
- Flags interdisciplinary and integrated activities.
- Focus of STEM advocacy: Engagement, agile problem solvers and inquirers, authentic problems, innovation and creativity, design, digital literacy.
- Future proof students.
- Challenge to develop coherent curriculum.
- STEM not sum of individual disciplines.
- Meta meaning of word STEM is important.
- Is STEM a coherent narrative? STEM, STEAM, STEMM, ESTEM, STM-HAS ? What is common and what is different? Where is/is not the STEM? Each of these has different epistemologies etc. and in relation to curriculum and policy.
- Interdisciplinary STEM in schools? – Curriculum and policy in schools and for teacher educators.

Linda Hobbs

- Reporting on the Deakin STEM conference.
- School focused discussions.
- Discussions around possibilities of STEM.
- Share education practices.
- Promote cross-curriculum links.
- Students as active and flexible learners that are creative, confident and informed.
- Visited schools and participated in presentations and workshops.
- Focus: What is STEM? STEM in the classroom? Sustaining STEM in schools?
- Outcomes of the roundtable; What complexities involved in defining, generating, sustaining and evaluating quality STEM?
- Teacher focus.
- Quality = variety; alignment with curriculum and STEM practices; goals for learning concepts, skills, attitudes; assessing STEM achievement; individual projects or activities vs comprehensive vision of STEM.
- Defining = Local, regional and international differences; need this variety; different versions; STEM vs STEM education (translations); purpose of bringing STEM subjects together?; no fixed definitions and require flexible definition that meets needs of individual schools; great way to engage students; teachers' patients and resources are important; need to allow variation so schools can set own path; dangers of forcing homogeneity; local variation but with a common language around STEM.
- Generating: framing, what look like, how use curriculum, how support teacher learning, how bring community and industry on board; time, funding and energy key factors; networking, collaborating and professional development are essential and exposure to what others doing and what occurring in industry is also important; have a clear plan, work with what already have.
- Sustaining: work out what level impact want to have; finding time; documenting; recruiting teachers to cause; support of a champion; community links; maintain momentum; literacy and numeracy; source and train STEM teachers from industry.
- Evaluating: do at different levels; teachers and academics need to work together; how measure success?; what does success mean?; who responsible for measuring success?
- Next steps: have a long term focus for long term learning and so students understand value of STEM; long term view for training and for teachers; need a common STEM language.

Perspectives on Integrating Elementary STEM Education – Professor

Richard Lehrer

Abstract: An integrated elementary STEM education is often advocated as creating opportunities for interdisciplinary learning. For instance, projects in engineering design may include forays into science, mathematics, and technology. These forms of integration are intuitively appealing because they seem ‘relevant’, but as implemented, they often obscure valuable distinctions in disciplinary ways of knowing. An alternative form of integration bootstraps interdisciplinary learning by establishing bridges between STEM disciplines while retaining their epistemic signature. I illustrate how engaging children in developing mathematical systems supports their efforts to model natural systems, preserving each discipline’s (math, science) values while establishing productive synergy.

- Integrated STEM education.
- SILO = reinvigorate disciplinary learning; silos needs to link
- Proving to resolve dispute (maths); students generate questions (maths).
- Constructing representations is a good way to learn science; what function do scientific diagrams have?
- Modelling ecosystems.
- Practice different forms of competency (combine silos) and so drawings and text etc. need to be integrated.
- Integrated STEM education: cultivate interest and identity (particularly for less well represented groups of people).
- Bridging; preserve disciplinary practice but establish resonance among different disciplines; need to trigger and cultivate interest.
- Modelling comes in material and non-material forms.
- Modeling growth.
- Circulating reference (see Latour).
- Relationship between model and reality is key (what happens when model not fit reality?).
- Bring thinking and modelling back to the physical system.
- Re-visioning relations among disciplines to increase likelihood of resonance between them; longitudinal view; how can teachers support student learning?

An Historical Perspective on STEM as a Schooling Goal – Professor Peter Fensham

Abstract: The international emergence of STEM as a goal for the 21st Century school science seems to be inexplicably associated with the demand for the skills that workers, at large, will need to have for a competitive national economy. These skills are generally, at least in science among the STEM subject areas, not being currently emphasised. This societal demand challenges school science at a time when it is still

coming to terms with the demand for public scientific literacy. An historical perspective will be used to discuss these and other purposes for school science and to suggest how and when they, if seriously intended, can find expression in the years of schooling.

- Many possible purposes for learning school science: prepare students who have an interest in further science-based studies; develop citizens who can participate in choices in society that involve science and technology; stimulate intellectual and moral discussions by students; prepare students for modern fields of work.
- Science for all Canadians – looks at purposes of school science.
- Each emphasis requires its own: supporting pedagogy; outcomes for students; content for learning; assessment.
- Traditional purpose always wins out if try to focus on these different emphases.
- Cannot do two things with the curriculum at the same time – traditional will win out.
- Target: future scientific professionals; develop all students as future citizens to be scientifically literate and participate in society; stimulate intellectual and moral growth; prepare students to enter STEM related fields of work.
- Buzzword is ‘skills’ for the economy of the future, but science education has never been big on this in Australia and is not often discussed.
- Purposes for school science and the science learning outcomes are directly related.
- Overtime the perceived purposes and thus learning outcomes for science learning have changed.
- How teach these skills? Many seem difficult to teach and difficult to relate to the real world and to what goes on in the classroom.
- Certain skills identified as important in science education and have ramifications for the teaching and learning of science: learning to learn (focus on metacognitive); learning to see alternative solutions to solve problems (open questions); learning to improve performance; learning to adapt to change and generate new knowledge (focus on emerging knowledge); learning to ask questions and formulate ideas; learning to communicate with different audiences (needs new assessment modes).
- Pressures determine what happens in school and currently it concerns the economy and the required skills, but what give up to achieve this?

Situating STEM Within a Funds of Knowledge Perspective on Problem Solving – Professor Julian Williams

Abstract: Although I have been critical of the Funds of Knowledge project

perspective because of its misunderstanding of capital, it might offer a context which marries both (i) the bridging of academe with home, community, and work contexts, and (ii) problem-solving from the learners own life-world. I will draw on examples, such as that of 5-year old Rico's photograph of his aquarium, and his identification of the home-mathematics of 'the shape of a fish' for inspiration. Then there was Bobby George, our famous darts player, who eventually was forced to work out the odds to avoid excruciating embarrassment at the oche. What would a STEM curriculum look like if it took seriously Rico's home knowledge or Bobby's professional identity? Finally, how might we conceptualise the 'disciplines' in STEM in a way that would help such a curriculum?

- STEM failing to engage many students because leads with the interests of STEM itself (capital oriented), whereas the focus should be on enhancing the lives of students.
- Subsume STEM in students' projects and must be led by students' interests and motives and lead to different dialogues and changes to the curriculum.
- Funds of knowledge approach is potentially valuable; focus on and interdisciplinarity and metadisciplinarity
- Putting the leaf on the stem (STEM). What is leaf and what is stem?
- Maths in STEM is a tough nut to crack.
- Re-envisioning STEM education: Curriculum, assessment and integrated, interdisciplinary studies - led by student projects and by students' interests and based on projects and protect assessment from the disciplines.
- Measure students' dispositions to studying maths and goes down over time.
- Transmissive teaching (delivery model of teaching); maths is suited to this and is associated with declining students' attitudes to maths.
- Maths seems to be good at annoying students and is because nearly every event is a test in transmissive teaching.
- Some students in classes with non-transmissive teachers enjoy maths, in particular discussing different answers.
- Measure students' views of transmission; students' perceptions of the classroom are really important.
- Higher up in school then get more transmissive and females perceive as more transmissive.
- Want to avoid essentialising factors, for example gender.
- Students' perceptions are the key.
- Need to try to Undo the alienation in maths.
- Students treated as the objects of teaching (students are taught as opposed to students learning)
- But learning requires a motive/interest/emotion too.
- Need two voices and need joint activity.
- Emotions are attached to real events and key developmental moments and could spark a developmental course that changes attitudes to STEM

(perezhivanie, see Vygotsky).

- Need to address the students' interests in STEM.
- Putting the leaf onto STEM and so critique the discipline and put to the service of students' projects and interests and so need to research perezhivanie.

Business Communities Supporting STEM Innovation in German Schools – Professor Günter Törner

Abstract: Professor Günter Törner reports on a German STEM (which translates as MINT in German) initiative of the business community designed to promote mathematics and science in high schools - the MINT-Excellence Centre (MINT-EC). The MINT-EC is mainly formed by industry and employers, and is running a network of 250 schools in which STEM is presented through a variety of activities. The schools receive some financial support to assist each other, and to start initiatives by themselves. Further, MINT-EC is providing projects overarching the work in the 16 provinces. Each year there is a joint meeting of representatives of these schools where there is something like a market of ideas. Importantly, the principals of the schools are invited and acknowledged, and are provided with training in areas of THEIR interests by German companies. Thus MINT-EC schools are professional learning communities where principals are included and specifically addressed.

- STEM in Germany is promoting through industry.
- Cooperation with industry is key.
- Many German school systems and so no standard curriculum due too many compromises.
- STEM = MINT (maths, informatics, sciences, technology).
- Open boundaries; STEM is a fussy term.
- Need for STEM qualified students in the job market.
- Restrictive acceptance into maths and science.
- High drop out rate for engineering.
- No cooperation between STEM faculties in unis.
- No joint STEM curriculum with the German school systems.
- MINT-EC network = Business community initiative to promote maths and science in high schools to activate young STEM talents and these schools claim to be good at MINT and must prove worth.
- Nationwide network of excellence for schools with STEM focus and offers outstanding programs for students and teachers and so fosters and empowers the students to work in STEM jobs.
- Continues student support.
- Cooperation between schools, unis, companies, research institutes is critical.
- Develop and train STEM teachers.

- Optimisation of school management in order to foster exchange and cooperation of schools.
- Strengthen the self-organisation process of schools as STEM focused schools.
- STEM camps.
- Programs for promotion of STEM excellence.
- Forums.
- Headmaster meetings.
- Conferences and professional development for teachers.
- Interdisciplinary network cluster.
- Alumni network.
- Professional public relations –via emails etc.
- Many teachers and schools involved.
- Highly effective network.
- Be open-minded.
- Self-regulating network.
- Change school culture.
- Get principals and teachers on board.
- Apply for MINT label.
- Get on with political stakeholders.
- Need more STEM friends.
- Teacher education to contribute to STEM.
- Awards.
- Start science education in kindergarten.
- Need STEM journal?
- STEM ambassadors could play an important role.

Roundtable:

J (primary school teacher from small school)

- Need a champion to push for the cause.
- Need maths/science specialists and need to invest time and money to train, but there is always the risk of losing the champions.
- The issue of schools being cash-strapped is significant
- Need to find driver for STEM within the school.
- Need a model of good practice to use as a guide; what are the expectations and what meant to put in place to cover the initiative?
- Having a curriculum agenda that is governed from the top down, which operates as an important driver, can be an issue.
- Is there a neo-liberal agenda at play?
- At the primary-level there is a need to develop students' transferable schools and not about training for jobs.

- Need money to enable to attain drivers and maintain these drivers.
- How and what assess? What expect in assessment (as STEM or as individual subjects)?
- Students are very tech savvy and do not need to teach these base skills.
- What students know has changed and will continue to change and so must teach different skills than in the past.

R (STEM enthusiast group)

- STEM is often seen as solving a workforce and economic problem.
- But what does STEM mean for teachers?
- Need to look forwards and not look backwards.
- Students need to learn how to learn things differently.
- Must provide students with opportunities.
- Do not dismiss as too hard or not relevant.
- Need to better match tech that students use to what they do in schools.

J (academic)

- Not new ideas as to why need STEM and have been evident in past efforts to reinvigorate science.
- Why think will be successful this time? – More enthusiasm? More political support?

J (academic)

- STEM less likely to succeed as more formal than used to be.

J (STEM enthusiast group)

- Students interested in STEM related issues are exploring these in non-school settings because is cheap and easy.
- Doing creative things with STEM stuff in non-schools settings.

R (academic)

- Not equitable as not cheap and easy to access for everyone and so need to bring into schools.
- If want STEM to succeed in schools then need to change school structure and other factors (school-wide change needed).

R (academic)

- Contradiction between performativity and creativity.
- Focus on numbers (quantification) forces to pick low hanging fruit, but focus supposed to be on creativity and problem solving etc.
- STEM agenda is critique of how disciplines operate in schools and need to consider how see authentic project work and how disciplinary practices occur and manage project work and interdisciplinary practices.

D (academic)

- Interdisciplinarity in science in schools not what scientists are doing.
- Need to consider what contemporary science and maths is about when think about science in schools and interdisciplinarity.

L (academic)

- Much variety in what schools see as constituting STEM.
- Schools need to see that attending to certain needs and to see evidence of this otherwise focus on STEM is not useful.
- Assessment is a big issue (what assess?)

G (department of education)

- Not an 'us and them' situation.
- Schools know what's best.
- STEM is not once size fits all.
- Schools adapt curriculum etc. for themselves.
- But still need to pay attention to the curriculum.

J (primary school teacher from small school)

- Curriculum is murky.

G (department of education)

This murkiness could be productive.

R (academic)

- Need to look at assessment regimes that address STEM (e.g. creativity and problem solving).

G (department of education)

Looking to assess (in particular the VCAA) critical and creative thinking.

J (primary school teacher from small school)

- Is creativity and critical thinking not already embedded in other disciplines?
Or should assess individually within the subject areas?

G (department of education)

- Need to assess individually within the subject areas.

D (academic)

- What is it that STEM is offering us that is new?
- It is a socio-political construct and academics use it to galvanize activity and not matter if ill-defined for it still enables collaborative implementation, but need to make clear what want to achieve.
- Is there a new goal or is there a new approach that is newly afforded?

R (STEM enthusiast group)

- Teachers do not have a voice in the dialogue.
- Teachers only have voice at school level and could offer something new.
- If teachers have agency then can be more creative.
- Teacher needs time and space to talk about the curriculum and often teachers are reluctant (time is an issue) and so STEM is an opportunity and gives teachers another go to be professional.
- Science inquiry and engineering design and the latter is often not a skill of teachers.
- Teachers can broaden there task if also consider the engineering aspect.