Could your school have a STEM emphasis?

What is STEM?

There are various descriptions of STEM (Science, Technology, Engineering and Mathematics education around the world. In the USA it includes the fields of Chemistry, Computer and Information Technology Science, Engineering, Geosciences, Life Sciences, Mathematical Sciences, Physics, and STEM Education and Learning Research. Partly differences in what is included in STEM arise due to different views of technology and the levels of integration of the subjects as they are combined or not, in curricula design. In the international arena, technology tends to be synonymous with ICT. In New Zealand, we have a separate subject domain called technology that includes design for innovation through technological practice, knowledge, and understanding about the nature of technology. Effective communication, including the use of information technology, collaboration, problem-solving, creative and critical thinking skills are fundamental to STEM.

The need for emphasis on STEM

Today, we face more complex challenges than we have ever faced before: a medical system that holds the promise of unlocking new cures and treatments yet an obesity problem (amongst other health issues) that has escalated heart and vascular diseases amongst our young; a system of renewable energy production that powers our economy yet many companies are downsizing due to the drive for efficiencies in human resourcing; issues related to stewardship of our land and water; threats to our biosecurity and privacy issues that exploit the very interconnectedness and openness so essential to our prosperity; and challenges in a global marketplace which link dairy farmers to tourists seeking the elusive 100% pure to China -- a marketplace in which we all share in opportunity, but which is also in crisis. No one can predict what new applications will be born from research: new medical treatments or new sources of efficient energy; new innovations in engineering; new technologies in electronics and information sharing; new building materials; new kinds of crops more resistant to heat and to drought and many more.

How we engage young people with authentic STEM experiences by connecting them with people working in these fields will help to propel their enthusiasm and excitement to develop a restless curiosity and fascination with the world and how it works. It may also assist them to see that participation in STEM education as a way of generating new ideas that can lead to careers that will contribute to the quality of life.

Therefore the development of STEM is more essential for our children, our people more generally, our prosperity, our security, our health, our environment, and our quality of life, than it has ever been before. The vision is to inspire young people through engaging in science, technology, engineering, and mathematics education to develop their creativity, problem-solving and employability skills, to widen their choices and chances for future careers with potentially higher remuneration than unskilled work. A focus on STEM can also help people to be well informed about and be able to engage fully in debate, and make decisions about STEM related social and ethical issues.

Given the importance of STEM education for young people moving into careers and for their lives more generally, there are associated agendas and strategies for improving STEM engagement through Continuing Professional Development of teachers and research on learning in STEM contexts. Recently, Conner (2013) indicated that students can use their intellectual capacity to develop new knowledge as part of learning about Science (Technology, Engineering and Mathematics). There is some evidence that this is more likely when students experience *being* scientists (or Health workers/ Technologists/ Engineers) through participating in meaningful activities (Bielaczyc, 2011; Linn et al., 2004). Engaging students in thinking about the future and their role in designing it, provides promise of positive futures which is motivating.

Compelling drivers and opportunities

1. STEM could be a focus for schools of the future are predicted to become critical sites for promoting health, environmental vitality, student wellbeing, academic growth and as connectors across their communities
2. The opportunity to increase choices and chances for students to engage with STEM – related knowledge, skills and practical experiences
3. Opportunities for continuing staff professional development and developing on-going support for more teachers of STEM related studies at all levels of the education system
4. Opportunities for connections with neighboring and contributing schools as well as tertiary institutions and CRIs.
5. Highlight the importance for students to engage in authentic learning experiences that would be relevant to their academic learning, their personal interests and provide challenging experiences in work-related situations (planning, design, building, engineering, innovative products, health promotion, allied health services etc)
6. Connections with businesses and potential employers
7. Opportunities for networked learning, research and disemmination for all involved
8. Peter Gluckman's (2010) report on *Inspired by Science* called for the need to emphasise science (and technology) at years 7 and 8. This is an ideal time to profile an emphasis on STEM for students to have a focused experience at intermediate or High School.
9. An emphasis on STEM also presents an opportunity to align teacher professional learning directly with research on authentic learning in STEM contexts. Through partnerships with the tertiary institutions, teachers can create opportunities to engage in targeted professional learning, inclusion in research projects and opportunities to enhance their teaching within a community of practice.
10. The most recent summary of PIRLS and TIMSS touched on some of the key findings for New Zealand, with both studies providing snapshots of, and trends in, student achievement. At best the achievement in reading, mathematics and science for New Zealand students as a whole, has remained static since 2000, with no positive shift in student achievement. In addition, the data from these studies indicated worrying signs of declining performance in middle primary school science and to a lesser extent mathematics. It is clear that continuing to do more of "the same" will not make a difference to student outcomes, We have to think and act differently if we are going to address the achievement gaps of Māori and

Pasifika students in particular, but also if we are to raise the awareness knowledge and skills of learners to participate in STEM related careers.

Strategies for implementation

Multiple strategies that target a coherent approach to STEM are likely to make more of a difference to students' experiences than a "potted", ad hoc approach. Some of these can be gleaned from what has been done in other countries. The UK National Science Learning Centre (2012) white paper made the following seven recommendations related to STEM education:

Recruitment and retention of specialist teachers

• commit to sustained funding of attractive bursaries for STEM graduates to train as teachers
• provide placements in schools and colleges for STEM undergraduates, to encourage take-up of initial teacher training
• dedicate long term core funding for subject specific Continuing Professional Development (CPD)/ Learning.

Career pathways

• establish clearly defined, long term career pathways for teachers and technicians
• require STEM teachers to be engaged in subject specific professional learning throughout their careers
• recognise schools that enable STEM teachers to engage in subject specific professional learning and hold those that do not to account

STEM teachers as STEM professionals

• require STEM teachers to keep up-to-date with developments in their fields
• support the provision of funded opportunities for partnership working, including placements, sabbaticals or engagement in collaborative research with universities, business and industry

Primary science

• ensure every primary school has access to a teacher who has specialist training in primary science
• provide long term support for specialist training to develop primary teachers as leaders of science

Accountability measures

• incentivise schools and colleges to provide an enriched and enhanced STEM curriculum, including links with employers, quality practical experiences, and research in schools, in order to maximise positive impacts on pupil achievement
• ensure national assessment includes students' abilities to solve problems, apply scientific principles and carry out practical work alongside their core bodies of knowledge

Leadership and governance

• encourage STEM teachers into strategic leadership roles in schools and colleges
• articulate clearly to STEM businesses the benefits of employees taking active roles

in school and college governance
• require governors to monitor a range of accountability measures including quality of careers advice and progression routes to a full range of post-16 provision

Context and careers
• ensure all schools and colleges provide high quality, age-appropriate careers information and advice
• embed the applications and relevance of STEM throughout the curriculum, from primary to post-16
• include all post-16 routes in progression measures

Internationally, there are groups of educational institutions at local and national levels in various countries that focus on STEM. For example the goals of STEMNET (UK) are expressed as:

1. Ensuring that all young people, regardless of background, are encouraged to understand the excitement and importance of science, technology, engineering and mathematics in their lives, and the career opportunities to which the STEM subjects can lead;
2. Helping all schools and colleges across the UK understand the range of STEM Enhancement & Enrichment opportunities available to them and the benefits these can bring to everyone involved;
3. Encouraging businesses, organisations and individuals wanting to support young people in STEM to target their efforts and resources in a way that will deliver the best results for them and young people.

STEMNET uses local STEM ambassadors, STEM clubs and an extended advisory network. Similar goals could be derived for Intermediate and High Schools or colleges in clusters of neigbouring and contributing schools in partnership with tertiary institutions. The development of this initiative could connect with these networks and potentially contribute to national and international developments in science, technology, engineering and mathematics education initiatives.

In the USA there is a STEM Education Coalition that represents all sectors of the technological workforce – from knowledge workers, to educators, to scientists, engineers, and technicians (http://www.stemedcoalition.org/). The participating organizations of the STEM Education Coalition are dedicated to ensuring quality STEM education at all levels. The coalition is made up of educational institutions (schools and tertiary institutions) and businesses who work together to promote the development and diversity of the STEM workforce pipeline. They have targeted initiatives to promote the inclusion of underrepresented minorities, women, veterans, and rural populations in STEM related occupations and to attract and retain talented and effective STEM subject master teachers and teacher specialists from all backgrounds. In this scenario, STEM acts as an attractor and incubator for innovation and careers development.

With few natural resources at its disposal, Korea's achievement in joining the ranks of the high-tech nations of the 21st century was due to the driving emphasis in schools on science and technology to develop its human resources. Korea has remained for years at the top in both the PISA (Program for International Student Assessment) and the TIMSS

(Trends in International Mathematics and Science Study) international comparative league tables, together with other educationally advanced countries. This rise in achievement is attributed to a strong social emphasis on the importance of *investing* in and highly valuing education at all levels, from personal to corporate to governmental, as well as to businesses recognizing their role in supporting educational advancement (MEST/KEDI, 2009). For example, the Samsung Institute of Technology (SSIT) is a company-run university in Korea offering bachelor's degrees. Hyundai offers in-house classes and internet lectures to its employees so they can get the credits they need according to their position in the company. Since 1983, Korea has developed *Special Purpose High Schools* in science to educate students with an aptitude for science. These schools emphasise content and skills related to Engineering, Agriculture, Marine and Fisheries and Maritime. The schools are given more autonomy in student selection and curriculum operation. Subsequently there have also been other Special Purpose High Schools developed in Korea for Foreign Language, International, Physical Education, and Arts.

In Singapore, through their ICT Ministry driven master plans beginning in 1997, IT infrastructure and teacher training was set up for all the schools in Singapore. Teachers were expected to acquire basic proficiencies in IT integration through training programmes run by the National Institute of Education (NIE). Every school was also provided with one IT Assistant (Centre for Science, Development and Media Studies, 2006). The emphasis has since been on integrating the use of IT for active learning of both pupils and teachers in their areas of curriculum development, instruction and assessment as well as whole school improvement through evidence gathering and research. Pupils' learning is assisted by in-school Learning Management Systems (LMS).

Summary

In summary, there are huge opportunities for students and staff by identifying as a STEM school; for learning, work-related experiences by connecting with businesses and industry, extended opportunities through links with tertiary institutions and on-going professional learning. However, it would be wise to take a coherent approach that continually questions how proposed activities align with the schools' goals. The learning for students and staff needs to enhance those outcomes that are valued by the community within which the students live. Momentum can be sustained through embedding inquiry and knowledge-building processes into the 'core' business of the school. For success, coherency needs to be established across teaching processes, new initiatives, and professional learning plans for teachers (Timperley, 2011). While a focus on STEM requires a concerted effort on specific STEM-related learning areas, there will also need to be value placed on gaining knowledge and skills in other learning areas as they are very necessary for a holistic approach to any educational experience.

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