

Premier’s Commonwealth Bank STEM Teacher Scholarship

STEM deeper learning

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# Introduction

Science, Technology, Engineering and Mathematics (STEM) learning has been a focus in research, education and media recent years, based on the need for an increase in tertiary graduates with STEM skills. There is an increasing amount of research into STEM interdisciplinary curriculum completed with much focus on how teachers construct learning to integrate the learning areas and how the use of technology is integrated seamlessly to support student learning. This study will support the STEM learning I have led as deputy principal in a New South Wales primary school by conducting research into the processes schools follow to create deeper STEM learning experiences that connect students to their community. This research will provide evidence of how case study schools create opportunities for deep learning through real world curriculum. I investigated how schools connect students to their community, local and global through STEM education. I hope to gain a greater understanding of the impact on student learning and engagement and achievement of the Melbourne Declaration on Educational Goals (2008), for students to become ‘successful learners, confident and creative individuals and active and informed citizens'.

The focus of the study is to review and understand how primary and secondary schools develop STEM integrated curriculum that digs deeper into meaningful real-world contexts, finding problems and designing solutions. Through this research it is expected to discover how schools develop students' skills that support STEM learning such as entrepreneurial and design skills, computational and scientific thinking skills to support social ventures, providing ongoing learning opportunities that produce sustainable product/projects for a community.

# Focus of Study

The focus of the study is to discover what processes schools use to create deeper STEM learning experiences that connect their students to community and social enterprise. Questions focused on:

* How do schools create opportunities for deep learning through STEM curriculum?
* How to schools develop contextually meaningful deep learning?
* What is the evidence of the impact on student learning?
* How is social entrepreneurship and humanitarian engineering used in schools to connect students to their local and global communities?

# Significant Learning

Throughout the study tour, two major themes emerged; STEM curriculum integration and the importance of horizontal connectedness – within curriculum and learning and connectedness of students to community and each other.

## STEM K-12 learning

The implementation of STEM learning varied in each of the schools studied, however the schools all used student led, inquiry learning or Project Based Learning (PBL) pedagogy to scaffold learning. There were three ways that the schools visited integrated STEM learning; through multi-disciplinary learning experiences beyond STEM, that included humanities and the arts; humanities and STEM learning were kept separate; and one high school focused on discrete STEM disciplines.

### Multi-disciplinary learning beyond STEM

All STEM learning is multi-disciplinary in its nature; however, at Latitude High School in San Francisco they are working towards creating a truly integrated curriculum inclusive of STEM, humanities and the arts. Latitude High School opened in July 2018 to its first cohort of Year 9 students and when I visited, the school had only been operating with students for nine months. A strong example of how the school develops multi-disciplinary learning embedded with real world experiences and connectedness to community, is the changemakers project. The project included humanities and STEM learning to learn about changemakers in their local community through cycles of inquiry, excursions, interview and research. Students chose a local changemaker and conducted initial research by interviewing the subject, recording the interview and taking notes. Students wrote about their subject and created a podcast, which is shared with the wider community called Oaklore. The STEM learning linked to the project by students building an audio speaker to gift to their chosen changemaker to listen to the podcast. Students engaged in STEM through learning about circuits and coding with Arduino software and controllers. Students used the design process to design and create a working speaker.

Through speaking with students about the project, I could hear the school’s habits of mind and learning competencies being discussed. They were unprompted to use these throughout the discussion and it was clear that the school works hard to develop these skills in their students in all learning experiences. Students were able to talk about resilience and grit in learning, learning from your mistakes and the iteration process of learning and refinement. These skills underpin STEM learning and develop student abilities in learning beyond the classroom and school. This development of these transdisciplinary skills (which are aligned with the NSW Syllabi’s general capabilities) through STEM learning is relevant to NSW schools as these capabilities are a core component of our curriculum.

### STEM learning in isolation

Throughout the study tour, many schools taught STEM curriculum in isolation from other subject areas and not through whole curriculum integration. During my study tour, I visited schools that were not required to cover mandated curriculum, syllabus or content in any learning area, as they were charter schools or private schools. This is very different from the New South Wales context, where curriculum K-12 is full and fast-paced. The schools visited in the USA develop their own curriculum, some purchase curriculum from an external provider; other schools give teachers the responsibility to develop their own curriculum. All schools have the focus of creating college ready students; therefore meeting college entrance requirements is a focus of curriculum design. In each school, STEM learning was student centred, focused on learning and applying skills in context and connected to the real world and community.

At Windward School, a private, Year 7-12 school in Los Angeles; Nueva School, K-8 private school for Gifted and Talented students in San Francisco; and Portfolio School, K-5 private school in New York, they have set up workshops or a makerspace with a focus on Science, Technology, Engineering, Art and Mathematics (STEAM) learning. All three schools support this by funding a specialist teacher or tinkerer to lead learning in design and fabrication of projects using technology such as: robotics and coding, circuits, woodwork, metal work, 3D printing - almost anything that the students and teachers can dream of. Design thinking processes permeate classroom learning in all schools, this is supported through teachers using student centred learning pedagogies to further engage students in their learning: Challenge Based Learning pedagogy at Windward School, PBL pedagogy at Nueva School and inquiry learning processes at Portfolio School.

Many of the remaining schools I visited during the study tour divided learning in the school into STEM and humanities (English-writing and reading and history) classes, with specialist teachers leading these in elementary, middle and high schools. To support deep learning in these in areas, longer times for each period were given per day, 90-120 minutes per day at a minimum. Schools that used this approach included: High Tech High (multiple campuses K-12), San Diego; San Diego Met High School, San Diego; Fannie Lou Hamer Freedom School, New York; Los Angeles School of Global Studies, Los Angeles; Capital City and Two Rivers Elementary Schools, Washington D.C. These schools used consistent school wide pedagogical approaches to learning either using PBL or inquiry learning pedagogy to support deep learning and real world application of skills and knowledge.

### Discrete STEM disciplines

The STEM Prep Academy (High School, Years 9-12), in Los Angeles uses ‘Project lead the way’ curriculum, which links student learning to career preparation. The school adapts these units to suit their integrated curriculum model and use of PBL pedagogy throughout the school. The STEM Prep Academy also have an elementary and middle school, and STEM programs are developing in these schools. The way STEM learning works at this school is that when students enter the school in Year 9, any student who demonstrates grade level proficiency in English, maths and science can choose any of the STEM pathways - biomedical science, engineering or computer science. Each pathway is four years of learning and students can be accelerated within this as required. The students continue to engage in general English, mathematics, physical education, Spanish, and general science learning. If students are below grade level in the base subjects, they complete support classes to attain grade level proficiency. Usually about 40% of students enter Year 9 at grade level and proceed to begin their STEM pathway focus. Throughout Years 9-12, as students reach grade level proficiency, they can choose to join the STEM electives, which are multiyear level. The STEM pathways are focused on students learning skills and knowledge to apply in the real world and an important part of the program is connecting students with professionals in the fields. Experts come into school to support learning and field trips are essential for the students to experience industry. An interesting note is that the engineering capstone project students are paired with an engineer as mentor to complete their project and develop in-depth knowledge and skills, with a focus on working as an engineer.

### Deeper learning

To develop an understanding of effective components of deeper learning, I participated in the 2019 Deeper Learning Conference held in San Diego. The three days of learning was based around the deeper learning competencies; ‘content mastery, critical thinking and problem solving, collaboration, self-directed learning, effective communication, and academic mindsets’ (Deeper Learning Hub, N.D.). Through participating in this conference, I was able to build my knowledge of how schools in the USA work toward and achieve deeper learning for their students in different contexts and in varied ways. PBL, inquiry learning, design thinking, and STEM learning were prominent features in many of the sessions, as were equity in learning and wellbeing of students.

I was particularly interested in learning how schools are assessing student skills and abilities in the deeper learning competencies, which are not too dissimilar to the New South Wales K-10 Syllabi, General Capabilities. I will focus on this area, as I attended a whole-day workshop on this and it is very useful in supporting STEM learning in schools. To assess deeper learning, many schools in the USA require students to complete a portfolio defence, where they present and discuss their learning with teachers, peers, parents and experts in a formal presentation. What underpins these defences is the school’s graduate profile, which generally includes cognitive, personal, and interpersonal competencies that students develop throughout their school life. Through this discussion of learning, students articulate their expertise in each of the graduate profile elements. To support students, teachers and the school community in developing these competencies, shared rubrics and common protocols are established to ensure consistency and clarity of skills. The graduate profile and competencies are at the forefront of learning daily and used as a focus for reflecting on learning by students and teachers. This focus on the graduate profile and competencies was seen in visits to all schools and most notably at Fannie Lou Hamer Freedom School, New York, Los Angeles School for Global Education and San Diego Met High School, where I spent time with students and teachers learning about portfolio defences and each school’s processes for developing these skills in their students.

## Horizontal connectedness – wellbeing

Moving beyond integrated curriculum, learning should build horizontal connections between students and their communities, both local and global. I observed this principle in all of the schools I visited, it was highly valued by all leaders, teachers and students I engaged with. Practices varied, however almost all had a focus on building strong ties between students and their community, and through service learning. The middle and high schools visited all have an advisory structure to support every student’s wellbeing and build connectedness across the school. This varied from school to school, with essential features being a small group of students (10-15) supported by one teacher over a four year period. This enabled strong relationships to be developed between the adult and students, supporting students’ social emotional learning and academic development and strengthening communication and strong relationships between school and parents.

Many schools engage their students in service learning to strengthen student ties to their local community through supporting disadvantaged communities, younger students, older community members and giving back to people that have supported them. This also provides opportunities for students to discover professions and job opportunities that they may have an interest in for future careers. Students in the middle and high schools I visited complete internships at local businesses to prepare them for the real world beyond school. Some schools have students completing two days per week for three or six hours, other schools one day per week, or one week per year, depending on the context and charter of the school. Each school treats internships as a learning project, where students are required not only to participate in all aspects of the job they are doing, but to share their learning with their peers and teachers, connecting to their school’s graduate profiles and student learning goals. Many of these internships are in STEM related fields, however all employment opportunities are used.

Student learning is connected to real world contexts and issues through STEM and humanities learning, with experts supporting student learning inside and outside of the school. Students share their learning through public presentations at the school, in the community and via the internet, providing a real world impetus to complete high quality projects for a purpose. An example of this from Latitude High School was shared earlier in the report, although I could have shared an example of this from every school visited during the study tour.

### Entrepreneurial learning

Entrepreneurial learning is closely linked to STEM learning through the design process of ideating, iteration and production. I visited an Australian entrepreneur program based in Beechworth, Victoria, the Australian Centre for Rural Entrepreneurship (ACRE), and a local school that works with ACRE to develop their students’ entrepreneurship skills. ACRE’s aim is to build thriving communities in rural Australia through social enterprise and the development of local asset ownership by the community. In Beechworth, ACRE has worked with the local community to purchase the Old Beechworth Goal to further develop social enterprise in this regional area.

 ACRE works with local government to make projects a reality and operates the Social Enterprise Academy in Australia. The Social Enterprise Academy is the school program operated by ACRE in Australia. Social enterprise is driven by a public or a community cause - it could be social, environmental, cultural or economic. In the business world, a social enterprise would give 51% of their profit to a social cause. In the case of Social Enterprise Academy schools, they give 100% profit to their chosen social cause. This program is focused on empowering students to take ownership of their learning and their future through social entrepreneurship, developing their collaboration, communication, critical and creative thinking skills through real world application, and contributing to their local or global community in a positive way. Through participation in this program, schools have worked with local service groups to discuss what community issues exist in their area and how they are going to try to solve this problem.

I visited Whitfield District Primary School, Victoria, Australia to learn about how the school has developed their students’ entrepreneurship skills through engagement in the Social Enterprise Academy program. The principal discussed at length the positive impact this program has had on students and the community. Feedback included that students have had real world opportunities to develop general capabilities in meaningful ways and was a strong opportunity for curriculum integration of Science and Technology K-6 (design process); Maths and English outcomes are clearly visible throughout the learning. Community links that have been developed through the projects have been long lasting and the public are happy to be involved and provide useful feedback to students to keep improving. The school has been engaged in this project for three years and continue to value the impact that it has on student learning in STEM and in the strong community connections it fosters.

### Humanitarian Engineering

Engineering is a sometimes misunderstood profession, it conjures expectations that an engineer works in isolation and in one discipline to solve a problem. With the focus in the media over the past few years about engaging women in STEM careers and engineering, as a primary school educator, I wanted to learn more about how engineers support our local and global communities. I visited Engineers Without Borders, Victoria, Australia to learn about the humanitarian engineering work that engineers do to support communities in improving the lives of people. To do this you have to connect with the people you are working for, you have to know them deeply and understand their needs. Therefore, engineers need to possess strong skills in empathy and cross-cultural awareness, to be able to build an understanding of what communities are saying they need - not just what the engineer thinks the community need. As humanitarian engineering is focused on improving people’s quality of life, this would be beneficial to focus on when designing STEM learning in schools, to build student empathy and cross cultural awareness through real world contexts. This would provide authenticity, audience and action to be done by the students or audience.

I saw an example of humanitarian engineering used in the classroom at Nueva Elementary School in San Francisco, where the school has a focus on developing students’ global citizenship. Year 1 student learning is based on the theme of building. Students engage in an academic deep dive before moving into immersive learning and authentic projects. The aim is for students to really know and understand the design process and use empathy to design solutions to suit the end user. Students used the design process to build a community and/or family product to suit their needs. A further example is where Year 3 students are tasked with creating a game that does not have language or cultural barriers. This is linked with the year level’s global citizen theme. The students work through the design process and use knowledge that had been developed through the earlier deep dive and immersion experience to design, prototype and create a game. Visiting exchange students to the school are the authentic audience for this project.

# Conclusion

My scholarship was based on investigating deeper learning in STEM curriculum. Through school and program visits, and conference workshops, it is clear that for deep learning to occur in STEM curriculum, it needs to be focused on horizontal connectedness. Learning in the classroom should be connected to life, building deep connections between students and real world problems, occupations, organisations and other cultures. In this respect, I also believe that students cannot be disconnected from each other, their teachers and their communities, which is why I see the importance of embedding learning in work that matters, be it communicating ideas, solving problems or creating spaces for people to come together to learn. I echo the thoughts of many the educators I met during the study tour, that we need to engage students in learning that develops empathy, creativity, originality, social connectedness, purpose and passion. The learning that I observed during the study tour demonstrates how schools are achieving these goals and the impact this is having beyond the school gate. In addition to STEM integrated curriculum and development of deeper learning competencies, I believe that focusing on student wellbeing is essential in supporting all students to achieve. The advisory processes that I observed at almost all of the schools have been varied in application, but singular in purpose, to develop relationships and connectedness, supporting all students to connect, thrive and succeed.

All of these aspects are important to STEM careers, and as such for STEM learning in our classrooms. As Anna Cain, Engineers Without Borders, Australia stated in my first week of the study tour, Engineers support all communities, to improve quality of life... Human needs are at the centre of all engineering decision making. Engineering is about empathy first and foremost and then using specific skills and knowledge to help others (private conversation, 14 March 2019). This is important for us teachers to remember this as we develop learning experiences to prepare our students for their future.

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