

2017 Premier’s Mathematical Association of New South Wales Mathematics Scholarship

Science, Technology, Engineering and Mathematics (STEM) in the early years

A catalyst for encouraging curiosity, engagement and critical thinking.

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# Introduction

As an early childhood educator in a Department of Education Preschool, I have delighted in seeing children explore, investigate and discover – primarily through play-based education. Over recent years I have increasingly focused on encouraging children to develop their own lines of investigation, supporting them with questioning and the resources needed to find the answers that they seek. This prompted me to introduce many aspects of scientific concepts and processes into our preschool programming to enable children to investigate areas of interest with real purpose. After many discussions with colleagues I discovered that many early childhood educators were reluctant to engage in exploration of scientific concepts due to a lack of confidence or perceived lack of understanding. Similarly, whilst aspects of numeracy such as counting and numeral identification might be addressed, concepts of measurement may not be embraced to the same extent.

# Focus of Study

In this study I hoped to explore and identify elements of quality practice that allow Science Technology, Engineering and Mathematics (STEM) to be embedded across the curriculum and to promote children’s critical thinking and a culture of enquiry. Further to this the study, I hoped to identify elements of quality learning environments and engaging experiences at a range of settings. These will include schools, preschools, museums and science centres to determine what enables quality exploration and questioning. My study explored whether an innovative and creative curriculum in prior to school can be facilitated meaningfully in Kindergarten to Year two.

# Significant Learning

## Early Childhood Science Technology Engineering and Mathematics (ECSTEM) Conference, Pasadena USA

This conference was a fantastic platform to engage with other early childhood educators and find out about ways that STEM was being implemented into early childhood settings.

At this conference I was lucky enough to attend workshops where we were able to see examples of STEM in practice. One such workshop enabled participants to interact with a variety of stimuli to enable us to identify opportunities for STEM exploration. This workshop demonstrated a wide range of inexpensive and recycled materials presented for exploration. There was a leading question to guide exploration, but tasks were largely open ended. In this workshop participants shared ways in which they could extend learning through questioning. It was clear from this presentation that in to promote critical thinking a guiding question is necessary, but the variety of materials allowed scope for creativity and problem solving.

An additional workshop focused particularly on the Mathematics strand of STEM. In this workshop participants worked to complete challenges with a problem-solving element that also encompassed Science, Technology or Engineering.

This workshop enabled me to recognise that critical thinking and problem solving – inherent in mathematics – can be effectively harnessed with challenges. Literature was combined with mathematics to act as a catalyst for problem-solving challenges. Similarly, the use of technology to demonstrate concepts of addition and subtraction showed the opportunity for coding and technology to be used in authentic ways.

Throughout the workshops I was struck by the realisation that in some settings STEM was an opportunity to solve a problem or complete a challenge in isolation from the rest of the curriculum. This contrasted with what I believed to be the perfect opportunity to integrate the disciplines. As I continued my travels this belief was affirmed in many settings as I saw STEM used in authentic and creative ways.

## Kidspace Children’s Museum Pasadena

I visited the Kidspace Children’s Museum, renowned for the Robert and Mary Galvin Physics Forest and other outdoor elements, where children are encouraged to connect with nature and explore a variety of science and engineering concepts. In the outdoor environment, children were given opportunities to design and construct shelters as well as other opportunities to explore engineering. I was drawn to the simplicity in providing these experiences for children. The natural materials are readily accessible, and children could be given additional guidelines to define the parameters for construction. The opportunities for children to explore mathematic concepts such as measurement and geometry are evident within these outdoor experiences.

In the imagination workshop children are encouraged to explore and investigate a variety of concepts using mostly recycled materials. In this space creativity is encouraged and mistakes often lead to new discoveries. I particularly noticed the conversations taking place between the educators and the children participating in the experiences. There were many cases where children asked, ‘what do I have to do?’ when given opportunities to simply explore the materials presented to them. I reflected on how often students are given opportunities to freely experiment with resources to see what observations they can create. These students were then given a simple concept or challenge to provide some guidance. At this point many students eagerly engaged in the task and interacted with the resources. Finally, some students asked for direct instruction to complete a task. I further reflected on the support given to students in learning to think critically, solve problems and be willing to take risks. In preparing students to engage in mathematical and scientific processes, we need to prepare our children to understand that there are often many solutions to any given problem and more than one way to find those solutions.

## Caltech Children’s Centre

At the Children’s Centre at Caltech guided by the Executive Director Susan Wood, I observed a carefully designed learning environment where each element has been selected with clear intention. The learning environment was designed to be calming and aesthetically pleasing as well as purposeful. The children are viewed as very capable learners even from the youngest age. Teachers program and plan for experiences that expose children to mathematical concepts such as 1:1 correspondence and shapes, and scientific concepts such as gravity, chemical reactions and force. The curriculum is heavily influenced by literature which can be used as a catalyst for the exploration of these concepts. The literature selected also makes the concepts more easily accessible by children. In teaching these STEM concepts, vocabulary is intertwined and used repeatedly within the experiences.

Children are taught to design and create blueprints as well as to experiment and record their observations in science journals. Art techniques are explicitly taught and provide further opportunities for children to explore the science and mathematics concepts currently being investigated.

My visit to this early childhood environment caused me to reflect on the teacher led curriculum as opposed to the emergent curriculum followed in my classroom. I pondered about the opportunities that I provide to my children aligned with their interests as opposed to the set curriculum offered in this environment. I concluded that in following children’s interests, I was able to engage children in learning while still maintaining a focus on STEM concepts. I have also reflected on my view of children as capable learners and considered that the experiences and opportunities currently offered to children could be extended to take this into consideration. I have also considered the need for children to have multiple opportunities to explore and create understanding of scientific, engineering and mathematical concepts. This is often overlooked and something teachers need to consider to enable learners to have a firm foundation for experimenting, problem solving and forming conclusions.

## The Children’s Garden at Huntington Library and Botanic Garden

This garden provides a unique opportunity for children to explore nature and the outdoors through a variety of exhibits . It is themed by the concepts of earth, air, fire and water and each concept is addressed in many areas within the garden. Children are encouraged to be hands on in their exploration and concepts of time, cause and effect, and movement, all of which can be investigated in the garden’s features. After spending time observing children interacting with these garden features, it became apparent that once again the outdoor environment provides extensive opportunities for children to experiment with concepts and find their own conclusions. The time globe that casts shadows across the world in real time is a fantastic example of ways that authentic connections can be made with concepts such as time and space.

## Proton Preschool at the Pacific Science Centre Seattle USA

At the Proton Preschool, I was immediately struck by the educators’ welcome to their students. Each preschooler is recognised as a scientist and welcomed to the learning space eager to explore, investigate and discover. Children can articulate that they are scientists and their role at preschool is to learn and to discover new things. The learning environment at this setting is extremely small however the students also have access to the exhibits contained within the Pacific Science Centre. This is a unique setting which allows educators to connect directly with knowledgeable experts as well as the opportunity to interact with resources that are generally unavailable to preschools.

The curriculum is set by the teachers to provide children with a structured introduction to the concept for the week or period of time. All students are seen as scientists who can explore, investigate and discover. The introduction and ongoing use of vocabulary are a key component in the delivery of the educational program. Children demonstrated that they were able to incorporate the special interest words into their regular vocabulary and in the correct context. They confidently expressed their understanding of topics and made connections with their life experiences to create new levels of understanding.

This deliberate use of vocabulary to extend understanding reminded me that for the use of vocabulary to extend meaning, students must be able to incorporate the terms into the correct context while making connections with their background knowledge.

This unique setting provides students with access to facilities and experts that can facilitate and extend their learning. Students have the opportunity to explore the exhibits with careful guidance provided by teachers. The collaboration between the educators within the classroom and the educators of each area within the Pacific Science Centre was apparent and allowed students to explore concepts to an extent they may be otherwise unavailable in a different setting. This collaboration gave me an insight into the possibilities presented by forming partnerships with educators in other settings such as museums and science centres. By creating these opportunities, we not only develop the capabilities and understanding of educators on unique topics but enable students to explore concepts that previously may have been considered too difficult for young learners to comprehend. This also reinforces my previous thoughts about the need to view learners in early childhood as capable of interacting with and understanding diverse concepts and theories.

## Children’s Discovery Museum San Diego USA

During my interactions with educators at the San Diego Children’s Discovery Museum I was inspired by the connections with the local community. As educators we are aware of the need for students to be able to make meaningful connections with their background knowledge and their known contexts. At the San Diego Children’s Discovery Museum, the opportunities for connections to be made are apparent in all areas of the learning space. This happens particularly within the exploration area of the museum that is focused on world cultures and gives opportunities for children to appreciate the diverse world around them.

The local community is reflected within the design of the outdoor discovery and learning environment. There is clear reference to the cultures of the local population within the gardens and children are given opportunities to explore and investigate topics that are relevant to the local environment. There are is the many opportunities to investigate being water wise due to the lack of local water sources within San Diego. Visiting children were supported through a variety of experiences to explore how water is sourced as well as methods for saving water and solutions for preventing pollution. Children are presented with opportunities for free exploration as well as guided experiences in their visit to the museum.

During my time at the museum I was able to observe and participate in a variety of excursions, presentations and interactions with children. During these interactions it became apparent that questioning and guided experiences are most effective when students are given the opportunity find their own answers. Educators need to allow exploration, experimentation and at times failure to enable students to become active problems solvers who are capable of critical thinking skills. Probing questions to elicit thoughts about how and why, were most effective in supporting students to complete a task successfully. Students were also supported to reflect on how things could be done better even if their first response was successful. These elements are key to implementing STEM effectively in classrooms and early childhood settings.

## Fleet Science Centre

The Fleet Science Centre provided programs and opportunities for students of all ages to investigate and discover scientific concepts. I had the opportunity to engage in the early childhood program that provided children with opportunities to explore a variety of scientific concepts. During the sessions children were supported to participate in a range of experiments about a particular concept. I observed that although each experience presented had a clear focus, children were given autonomy to decide what materials they might use and how they would use it.

The reference to early childhood learners as capable was very clear. The children used a wide range of vocabulary to support their investigations and conclusions. In these programs, parents were key partners in their children’s exploration of scientific concepts. They guided their children through each of the experiments, but it was enlightening to see that many parents allowed the children to lead the direction of the investigation. The educators explained that this direction had taken place after some conversations early in the program. Throughout the various settings that I visited it was apparent that allowing children agency and support gave the greatest opportunity for children to engage in authentic and meaningful problem-solving skills.

## Children’s Museum

The Children’s Museum in San Diego was a unique setting where creative arts are incorporated into the exploration of many concepts. Children are provided with opportunities to investigate and explore using a variety of processed and recycled materials. In investigating the many exhibits available children can interact with the materials and discover elements of cause and effect. This was evident across all areas of the museum where children were able to pose the questions what happens if I…if I change this, then.... In implementing STEM across the curriculum, cause and effect is a vital concept for students when participating in problem-solving and critical thinking opportunities. The inclusion of materials such as paint and clay in the design process adds a creative element and provided opportunities to reflect on aspects of design that may or may not influence the desired outcome.

## High Tech High Elementary

During my time in San Diego I visited High Tech High Elementary school and discussed their programs. I was inspired by the real world, authentic tasks that offered students opportunities to present their findings to outside stakeholders. This level of accountability ensured an extra level of engagement by students and an opportunity to make connections with their local context. I observed an integrated curriculum with art, English, science, maths all intertwined. This again led to high levels of engagement for students and gave opportunities for problem-solving and critical-thinking processes to be explored to a deeper level as students engaged with a real world scenario.

The school utilised the expertise of knowledgeable educators to build the capacity and confidence of teachers to investigate concepts around Science, Technology, Engineering and Mathematics. Release time is planned in conjunction with classroom teachers to ensure authentic connections are in place for all aspects of the curriculum. Finally, I was inspired by the connection made with the local high school to participate in and scaffold students’ investigation of concepts. I saw this as a unique opportunity to develop a sense of community as well as support transition between the settings.

## Kennedy Space Centre Florida, USA

I next visited the Kennedy Space Centre operated by NASA, where I explored the facilities and observed endless opportunities for students to engage in problems-solving tasks. I was also drawn to the opportunities available for students to observe these skills being used to achieve success in an area that was once thought impossible. My time at Kennedy Space Centre inspired me to remember my initial reasons for becoming a teacher to inspire students to reach for their dreams and to instil in them the self-belief and determination to make their dreams a reality.

## Hamilton Elementary – School of Engineering

At Hamilton Elementary I was provided with many opportunities to engage with the students and teachers within the school. The school’s focus on engineering and innovation was evident throughout the school setting. I was interested in the concept of the integration of the engineering cycle across all KLAs. Students were actively engaged in their learning and the process was applicable to students of all abilities. Students who struggled to achieve outcomes were given the confidence to attempt tasks, as engineers are focused on continual improvement and innovation and errors are seen as part of the process. This thought process is key in developing resilience in learners of all ages and effective in promoting risk taking when problem solving. In addition to this, capable learners are given the motivation to refine and improve their first attempts, even when successful, as innovation and improvement are always possible. This mindset can be promoted across all ages and areas of curriculum.

## Academy of Science and Discovery – Northwest Florida

My final destination was the Academy of Science and Discovery – Northwest Florida. At this early childhood education facility, I was inspired by the commitment to exploring various science concepts through hands-on experiences. Students were actively engaged with their educators and the learning environment as they were guided through learning experiences. This setting provided a unique environment where they can access the exhibits of the Science and Discovery Centre as well as an outdoor environment encompassing green spaces and a boardwalk across wetlands. This serves as a wonderful catalyst for exploration and discovery.

# Conclusion

My study tour of the United States of America provided me with many insights into embedding STEM in early childhood education. I found that true integration was vital for children to make meaningful connections in understanding the world around them. I also discovered that while many educators may be incorporating elements of STEM in their educational programs, there is greater opportunity to develop critical thinking and problem solving through these disciplines. Finally, I concluded that these elements can successfully be integrated throughout all areas of the curriculum in K-2 and in doing so can improve resilience, creativity and engagement for all learners.