ABBOTSLEIGH

Clippings
Full STEAM Ahead

2019

Science

Technology

Engineering

Arts Mathematics

Contents

Clippings showcases diverse professional practices from across the Abbotsleigh teaching and learning community.

This edition of Clippings has been produced by Donna Moffatt, Director of Learning Innovation and Sally Ruston, Head of Junior School.

To STEM or to STEAM?

'Science is not a boy's game; it's not a girl's game. It's everyone's game. It's about where we are and where we are going.'

Nichelle Nichols (2015)

Growing up with a grandfather who was a research scientist and a mother who was a maths whiz, I was in no doubt that STEM was definitely 'everyone's game.' The school I attended was well ahead of its time (although I was not aware of this back then) as it was perfectly normal for boys and girls to study the highest levels of Mathematics, Science, English, the arts and humanities. Once I went to university though, I discovered that this was not necessarily the case in the vast majority of schools of that time.

In girls' schools the notion that subjects are gender specific is an anathema. Abbotsleigh's well renowned Headmistress from the 1960s, Miss Betty Archdale, is often quoted as saying, 'With education, women can do or be anything', and we firmly believe this. Indeed, throughout Abbotsleigh's rich and robust 134 year history, our girls have always studied what have been considered by some as 'boys' subjects or 'STEM' if you will.

Our girls have also combined the study of STEM subjects with the humanities and the arts: 'STEAM'. This is because the wonderful opportunities of experiential learning in STEM are limited to only Science, Technology, Engineering and Mathematics. With STE**A**M where the arts are interconnected, the limitations are removed and replaced with 'wonder, critique, inquiry and innovation' (Educationcloset, 2019). Indeed, as Albert Einstein once so famously said, 'Imagination is more important than knowledge. For **knowledge** is limited, whereas **imagination** embraces the entire world, stimulating progress, giving birth to evolution.'

Our technologically rich and very complex 21st century world is beset with extremely difficult problems that we are relying on our next generations to solve. Governments, universities and businesses everywhere are crying out for our students to become masters of STEM subjects. They must, if we are to survive, grow and thrive. We need to provide environments in which our girls love these subjects, master them and take them to the next level. However, this can only truly be accomplished if the **A** is not only, not left behind, but championed, taking an 'equal place at the table' with STEM. Indeed, research demonstrates clearly that individuals at the top of their fields are both intelligent and creative.

The articles in this professional journal demonstrate our girls' love of learning and the curiosity, creativity, intelligence and deep learning they experience. The articles also demonstrate the talent and dedication of our staff, and the passion with which these great educators are embedding STEAM across our whole school, Pre K-12.

As you read this journal, *I hope you capture a glimpse of the positivity, deep learning, vibrance, vitality and verve that is elicited as our girls are given real world opportunities for action-oriented learning that intentionally makes connections between Science, Technology, Engineering, the Arts and Mathematics.*

Megan Krimmer

Mrs Megan Krimmer
Headmistress

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The Coming of The STEAM Age

Julie Daly, Abbotsleigh Archivist

STEAM at Abbotsleigh has a long history, starting with our earliest students at our first site in North Sydney. Academic rigour was behind Miss Clarke's mission statement in the establishment of Abbotsleigh – she taught several subjects, mainly Mathematics, French, German, Geography and Botany.

Indeed, Miss Clarke's mission was such that 'masculine subjects such as geometry were offered to all students, at least until parents protested its suitability for only the exceptional female student,' (*The Lily and the Lion,* Susan Emilsen, 2000, p12). The School did offer extra classes for an additional fee, including Violin, Drawing, Dressmaking and Domestic Economy, thereby balancing academic rigour with subjects which may have appeased the parent who was searching for a school with a more homespun or genteel approach.

In 1888, the subjects that girls could sit for in examinations included Arithmetic, Geology and Algebra; two years later they could also sit for Latin and Geometry. In 1907, Abbotsleigh gained its first success in Physics in the junior examination, and in 1913, an Abbotsleigh student succeeded in the subject of Plane Trigonometry in the senior examination.

'Over the years the subjects our girls could study grew in number, as well as the exciting ways in which they were implemented, with STEAM continuing to have a special role at Abbotsleigh. In 1960, Physics and Chemistry labs and new Art rooms were built. The opening of these new laboratories was presented as evidence of a flowering of science within the School. In 1963, the Abbotsleigh Science Association was formed, 'bubbling with ideas', seeking to demonstrate – through astronomy nights and festivals of science – the fascination of scientific enquiry.' (*The Lily and the Lion,* p202)

'At Abbotsleigh, Science has grown in importance dramatically over the past five years; new laboratories have been built and an enthusiastic Science Club has emerged. With the Wyndham Report has come a greater emphasis on Science, not as a subject for the brilliant few, but, as English has always been, for all.
We realise that Science is not merely the adding of acid to metal and watching the fizz. It is indeed an exciting adventure of the mind... There is gradually being evolved a new type of pupil whose interests are varied enough to include drama and chemistry, poetry and physics, mathematics and music – all at the same high level.' (*The Weaver, December 1964, pp 11-12*)

In 1966 the Science Wing was opened, and then added to in 1971. Two high achieving STEAM graduates from Abbotsleigh include Elizabeth Denne (AOG, 1991) and Ruth Sanger (AOG, 1935), BSc(Hons), PhD (London), Fellow of the Royal Society. Currently Assistant Professor in the Department of Mathematics at Washington and Lee University, Elizabeth graduated from Sydney University with a BSc(Hons) in Pure Mathematics. Her current mathematical interest is in Geometric Knot Theory.

In 1950, Ruth co-authored *Blood Groups in Man*, the definitive textbook on human blood groups. The Ruth Sanger Awards are named in her honour.

In Ruth's own words, she was 'never top of the class' at Abbotsleigh and began her university science studies at a distinct disadvantage, as she had only studied the 'ladylike' science of Botany at school. With determination she tackled the Chemistry and Physics requirements of

her Science degree by cramming over the vacation and then winning the Caird Scholarship, which enabled her to do Honours. (*Around Abbotsleigh*, 2001)

The number of current subjects now offered, and the ways in which these subjects can be studied, would astound the likes of Miss Clarke and her students. What our girls now take for granted has been hard fought and many barriers have been removed.

Our current Abbotsleigh girls can study subjects which are no longer classified as masculine subjects, because in the words of Nichelle Nichols (actress and former NASA Ambassador), 'Science is not a boy's game, it's not a girl's game. It's everyone's game. It's about where we are and where we are going,' – and STEAM will take you there.

The Gift of Time

Donna Moffatt, Director of Learning Innovation

Just how do you secure a grant of AU$10,000 that is being offered for STEAM programs in independent schools across New South Wales? Do you try and build some form of equipment that can be used by the various faculties? Do you design and implement a drone program? Do you create a series of workshops for students run by external companies specialising in STEM education? Or do you rely on internal expertise? How do you sell your idea and secure that funding?

After much deliberation, we decided to apply for a grant on the basis that the one thing that educators need, in an already crowded day, is time; time to design, implement and assess interdisciplinary STEAM projects that excite students and lead to deep, engaged learning. It wasn't that we didn't have such programs in existence. As is often the case in schools, there were many examples of well-designed STEAM projects on both of our campuses. There was, however, no overarching strategic plan and the success of some of the projects depended upon a particular teacher being present. So, late in 2015, we set out to develop a whole school approach to STEAM from Pre K to Year 12 and asked the Association of Independent Schools in New South Wales to buy us time, in the form of a grant – to create, to collaborate and to implement.

Our focus involved targeting key stages across the school, namely Early Learning, Stage 1 and Stage 4, and one of the most important strategies we employed early in our journey was forming a whole school STEAM committee consisting of key leaders who drive curriculum in our context. This group included some ten educators from Senior and Middle Leadership, and one of their first tasks was to create a poster defining and highlighting the principles of exemplary practice in STEAM. This poster was shared with all teaching staff from Pre K-12 at a professional learning session where we also shared vignettes of what was happening around the school. This served the dual purpose of beginning with a shared language about STEAM and identifying 'champions' across both of our campuses.

In order to keep educating staff about STEAM, the committee continued to spend its time developing professional learning experiences. We ran lunchtime sessions, afternoons and whole days where experts shared programming ideas, teachers were up-skilled, and the principles of interdisciplinary, project-based STEAM pedagogy were discussed. Simultaneously, we focused on our champions. Working with the teachers in the key stages we wanted to target was one of our most important tasks and, to this end, we designed three planning days, one in each of:

- Early Learning – four teachers;
- Year 1 with specialist teaching staff – seven teachers
- Senior School – 12 teachers.

Each group spent an entire day being taken through a design process. While this time was not actually devoted to developing the specific projects, it proved extremely worthwhile in laying substantial foundations for STEAM teaching – why, where are we up to, where are we heading, what is possible, what might stand in our way, what will help us. These target groups then participated in two more of these days to plan specific projects as well as department meetings to share their planning with other educators. These days were very successful and, while it did mean that there was considerable organisation in covering classes, the opportunity for collaboration and program development was invaluable. High quality teaching in STEAM requires time for planning at all stages of the project – in the planning, during the learning and for reflection.

As well as additional staff resource during the project design and planning, dedicating staff resources to the projects during the implementation phase was another of our successes. For example, in Stage 1, we chose a Year 1 cohort as our targeted area. During the project implementation phase, we had many teachers working

with 48 students. This included the two Year 1 teachers, two teaching assistants, a Science specialist, two IT Integrators, the Director of Learning Innovation and the Director of Curriculum, Innovation and Design. A parent volunteer was also present. Having so many staff working with the students also meant that time had to be spent in collaboration. We view such staffing and collaboration as an essential component of the project's success and we now try to build time into teachers' schedules for collaborative planning.

It eventuated that digital technology was an integral part of all our STEAM projects and this continues to be the case. Consequently, a great deal of professional learning was, and continues to be, necessary for all staff. In Year 1 during the grant period, this included staff understanding circuitry, Makey Makey and Little Bits Technology. In Year 7, the requirements have changed every term but the thing that has not changed is the need for time – time for professional learning, time for staff to practise their new skills.

There is little doubt that the gift of time enabled us to make great gains in STEAM as a school. There has been a change in the way in which students think and problem solve. This is evident across all stages and ability levels. The teacher of one of the Stage 4 classes states that she has never observed such unsolicited use of mathematical language before. While we targeted Early Learning, Year 1 and Year 7, our professional learning program has encouraged and empowered other year groups to design and implement STEAM-based projects. Educators from Early Learning regularly present at national conferences on STEAM education. Our NAPLAN results have improved even further in Mathematics. We run a very successful Robotics Club in the Senior School and increasing numbers of girls flock to Young Engineers after class in the Junior School. In fact, all STEAM-based co-curricular clubs have increased engagement. For the last four years, we have had sufficient students enrolled to take a Senior Software Design and Development class. Every year, more girls enter tertiary studies related to STEAM professions.

Our challenge is that schools are very busy environments and ours is no exception. How do we continue to find the time to prioritise STEAM-based pedagogy which, by its very nature, demands integration of disciplines and collaboration between staff in different faculties and sometimes across campuses? Our Senior and Middle Leadership teams have done much to organise officially recognised time, but as we become more confident in designing STEAM programs, so too our ideas grow. Perhaps our next task is to use those creative problem solving skills so focused upon in STEAM to solve the question: *how to expand time.*

Space to Think

Sally Ruston, Head of Junior School

What is the relationship between physical space and thinking? Can the environment impact the quality of the learning? Why does place impress so markedly on how we feel and behave?

While it is undeniable that extremes of environments dictate behavior and outcomes, can the same be said for the four walls of a classroom? Of course, landscapes such as deserts and ice flows, and habitats such as prisons directly control human behaviour. Lessons not learnt here can result in deprivation and even death. Yet is there such an imperative to ensure an optimal environment for learning? The work of early childhood expert, Loris Malaguzzi in Reggio Emilia certainly attests to the environment being the 'third educator'.

'The environment should act as an aquarium which reflects the ideas, ethics, attitudes and culture of the people who live in it. This is what we are working towards.'

Principles of Space

Given then the power of the environment, what lessons were there for us as we sought to create learning spaces that broke through stereotypes around gender in the male dominated world of science, technology, engineering and mathematics? What should we be working towards? We understood the necessity of establishing a physical environment that our girls would find appealing, intriguing and thought provoking.

Knowing girls, we wanted to ensure that our new spaces were:

- Collaborative – where ideas can be safely explored, shared and refined.
- Aesthetic – visually appealing and filled with natural light to inspire a sense of wonder.
- Spacious – where learning can be messy and expansive
- Adaptable – where rooms can be flexible for flexible thinking.
- Agile – where furniture can be readily adjusted, moved and reformed.
- Organised – where storage solutions allow for resources to be easily accessible.
- Reflective – where the learning behind tasks can be documented and displayed.
- Technology rich – where tools are readily available to learn, think and tinker.

Knowing of our girls' facility with language and enquiry, we sought to create an environment that would harness these attributes and support the development of computational, creative and critical thinking. We wanted them to see themselves as competent scientists, engineers and mathematicians and have ready access to technology. Thus, an existing run-down space of more than 350 square metres was identified for re-purposing and development.

Space Creation

The planning process was long and exhaustive. What was to be a 12-week build extended to eight months. Persistence, ingenuity and creative solution finding were essential to ensure the following:

- The insertion of steel beams to allow the installation of bi-fold glass doors, creating flexible spaces.
- A brilliant flooring solution that was soft and warm to the touch yet highly durable.
- Furniture sourced beyond educational suppliers to meet our brief for adjustable, movable and aesthetic resources.
- Lighting solutions to create spaces that appeared to be naturally light filled despite incorporating long, dark corridors.
- Blank palettes to encourage student endeavour, with pops of colour on feature walls and in the seating to create energy and a sense of fun. White, write on surfaces and glass were installed throughout.

Through consultation with the girls, the rooms were named and quotes of scientific and literary giants were decided upon. STEM Street gives access to the Science Space, Technology Hub, Curiosity Lab and Mathematics Exploratorium. Albert Einstein's quote is emblazoned on the wall:

'Imagination is more important than knowledge, for knowledge is limited, while imagination embraces the entire world and all there ever will be to know and understand.'

So too are lyrics from *Willy Wonka and the Chocolate Factory*:

'If you want to view paradise, simply look around and view it. Anything you want to, do it.

Want to change the world? There's nothing to it.'

From *'Pure Imagination'*
by Anthony Newley and Leslie Bricusse

Thinking Space

The journey to create included failures, setbacks, re-thinks, lots of collaboration and compromise. The result is one of which we are inordinately proud and believe does justice to our intent of seeing Abbotsleigh girls able to do amazing things.

Three-Year-Olds as Theorists

Mary Santone, Early Learning Centre Educator

A group of deeply engaged three-year-old children had been gathered around the trestles for quite some time and were using ropes and buckets in a variety of ways, appearing to be testing out theories. As the children's teacher, I was immediately curious as to what it was they were trying to figure out.

I sat beside them listening and observing, keen to learn more about what was so captivating.

"I'm pulling the plane," said Harrison.

"Look, it's going up and now it's going down," explained Vivi. Avni watched carefully and attempted to pull the bucket up and down, just as she had seen Vivi do.

"Tell me more Harrison," I encouraged.

"Well, I want the plane to go up and down. The bucket is going up and down. If I pull this rope the plane moves," Vivi explained as she pulled the rope. *"Oh no, it got stuck!"* Patterns of play involving rope and pulleys began to happen daily as many of the children from the class became involved. Drawn in initially by excitement, the investigation was sustained by their curiosity and persistence to figure it out.

The children were given time and space to experiment, hypothesise and build theories. As teachers, we stayed close to listen, to question and to scaffold the children's ideas in order to take their thinking beyond the immediately obvious superficial level and move it to a more complex, deeper space. As time passed the children experimented with a range of materials.

Working with varying sizes, shapes and weights, their thinking was constantly challenged and their emerging theories tested.

This work was deeply rooted in problem solving as many challenges arose. Our teaching dialogue was constructed largely around probing questions that invited the children to think critically and creatively to formulate solutions.

As the children's work became more sophisticated, a provocation was presented: How to get a barrow load of sand from the entry gate to the sandpit.

The children immediately began planning with great enthusiasm, thinking of ways to move the sand from the wheelbarrow to the sandpit. Suggestions included a bucket, a smaller wheelbarrow or a spade. Multiple possibilities arose.

The children were invited to record their solutions and plans on paper, explaining them to their peers as they worked.

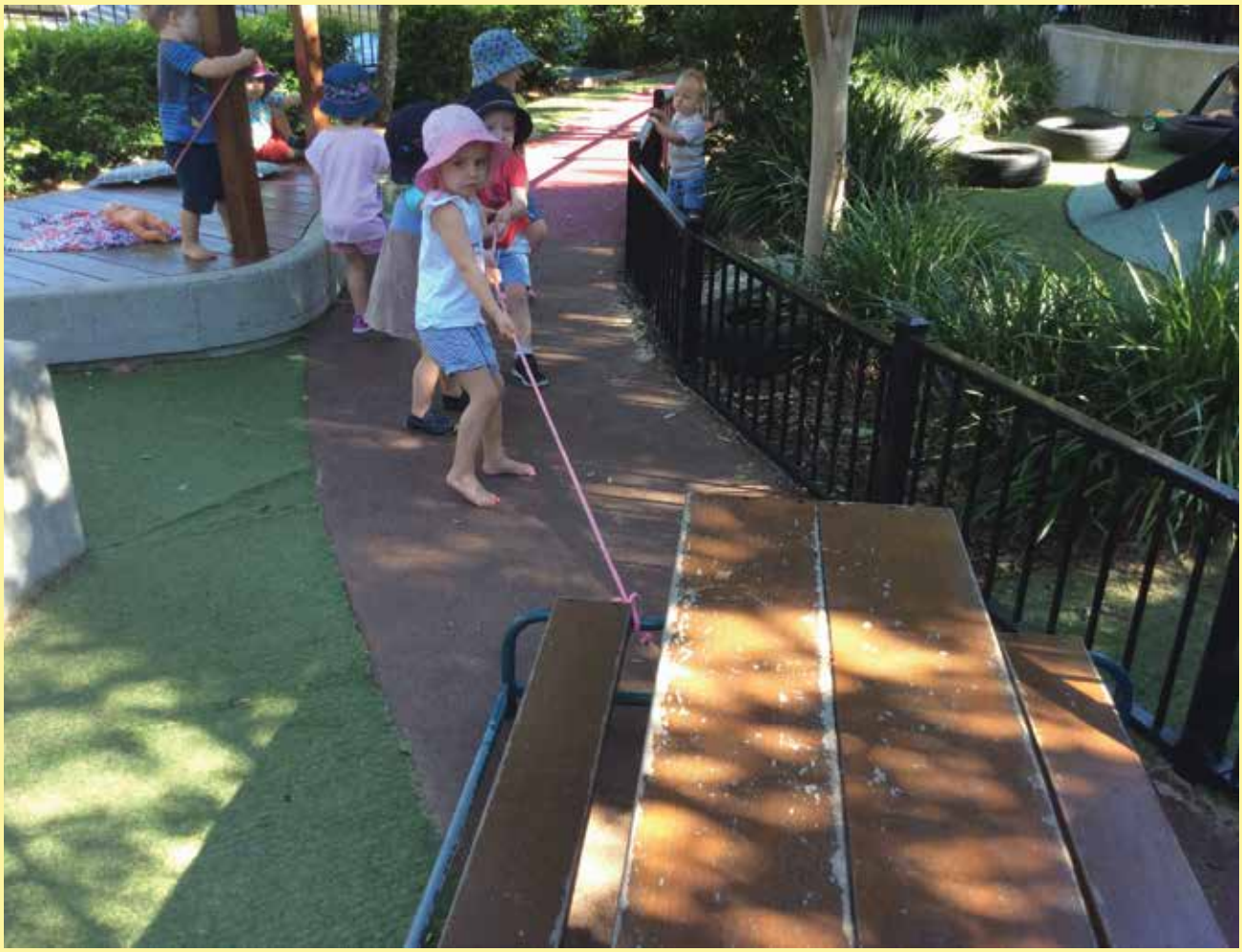
Armed with the children's ideas, we set about moving the sand to the sandpit. Over a period of time the objective was achieved through the rigging of a pulley system. What began as one child's desire to 'pull the plane' led to a rich,

deep, complex project that captivated the whole class and spanned an entire term.

What joy it brought to see the children's imagination, creativity, innovation and resilience in action and their confidence and persistence grow! The learning dispositions developed through this enquiry form a solid foundation for future learning. This sentiment is well reinforced by Claxton and Carr (2002) when they state:

"The fundamental purpose of education for the 21st century, it is argued, is not so much the transmission of particular bodies of knowledge, skill and understanding as it is facilitating the development of the capacity and the confidence to engage in lifelong learning. Central to this enterprise is the development of positive learning dispositions."

This project demonstrated so clearly that three-year-olds are great theorists.



Makers in Mathematics: Exploring the Use of Maker Based Learning Experiences to Engage Students in Numeracy

Nicole Hunt, Transition to Year 2 Coordinator

The importance of developing students' engagement with Mathematics has been highlighted as a key component of their academic achievement in this Key Learning Area. This is particularly significant when working with girls, with research identifying gender differences in confidence and self-efficacy when it comes to Mathematics[1]. With achievement levels often linked closely to emotional engagement in a subject[2], it is important to consider ways we can program and plan for Mathematics in order to create a more positive attitude towards this subject.

One educational movement that has been evolving in recent years is learning through the experience of making; or Maker Based Learning. Learning in this way involves placing the student in the role of producer, problem solver and designer[3], the aim being to create a culture where students believe they have the power to solve problems while highlighting the process involved in making, rather than the product[4].

With the maker movement in mind, the Infants and Early Learning students at Abbotsleigh have been involved in an action research project over the past two years to explore the impact of Maker Based learning experiences on the students' engagement and attitude towards Mathematics.

This project involved surveying the students in Early Learning, Kindergarten and Year 2. They were asked their most and least favourite activities during the school day.

The pre-test results showed that the students identified literacy-based activities as their favourite with creative arts and gross motor activities following close behind. A small percentage, between 10% and 15% of students, identified mathematical experiences as something they enjoyed the most. When exploring the least favourite activities of students, mathematical experiences fell between 7% and 20%. Additionally, the younger students with little exposure to formal schooling identified Mathematics as being homework and a boring thing to do. When asked what Mathematics was, students in Year 2 highlighted aspects of the number strand with no real links to real life application or problem solving.

With this in mind, a number of activities and experiences were planned in the hope of building a more positive relationship with the subject and a greater understanding of the application and use of Mathematics in the real world. Some of the projects are detailed below. Each of these experiences allowed for designing and making, while applying key mathematical concepts throughout the process.

The House that Transition Built

The Transition students were introduced to a picture book called *Clancy and Millie and the Very Fine House*. They took an idea from the book that centred around using boxes in imaginative play. From this, they designed and created a range of 3D objects to represent parts of their plan for a house using cardboard. The students developed a keen mathematical vocabulary as they discussed elements of 2D shapes that made up the faces of the 3D objects. They were able to identify the attributes of 3D objects that made them suitable for stacking and used this knowledge to build a large cubby house able to be used for play during recess and lunch.

Creating costumes with Kindergarten

With an empty costume trolley in the classroom, Kindergarten began pondering costumes and dress-ups that they might like to interact with. The project evolved over time and the students became engaged in a process of designing and making costumes with the intent of wearing them to celebrate being at school for 100 days and the things they had learnt in that time. The mathematical content was explored through the discovery of shapes in pattern making and measurement, with some students including other mathematical ideas in the way they decorated their material. They made models, patterns and cut the fabric for their costumes, which were sewn by adults. They completed alterations while at the same time

celebrating their mistakes when their outfits did not correctly fit.

Marble Run Madness

The marble run was presented to the Year 2 students as a competition based around developing a track that would either keep a marble inside for the longest amount of time or allow the marble to travel the furthest upon exiting the run. The students developed a plan, used recyclable materials to create it, tested and recorded their results and identified aspects that made their run successful or not. The mathematical focus was on recording data, 3D objects and measurement in terms of time and length.

These learning experiences and projects, along with others throughout the year, allowed Mathematics to be seen as a set of skills that can be applied to designing and making procedures. The hope was that through the act of making, students could see the ways that we purposefully use measurement, number and geometry in real life. The processes they were involved in highlighted the success they had in using their numeracy skills to design, make or create something new, unique and interesting.

At the conclusion of the year, the students engaged in a post-test. This included identifying their most and least favourite things to do at school as well as the experience or event they had been involved in that they enjoyed the most throughout the year.

The results highlighted that up to 38% of students now identified Mathematics as their favourite thing to do at school. In addition, the students in the Early Learning environments had more positive understandings of what Mathematics is and 50% of these students identified STEAM based activities as their favourite. Up to 70% of students in Kindergarten found various Maker-Based Mathematics projects their favourite thing to do throughout the year.

Although the impact of this type of experience on engagement in Mathematics is continuing to be explored through additional research in our context, the initial results suggest that these learning activities have helped to form positive attitudes towards this subject area. The maker-focused nature of these activities allowed students to participate in learning processes that were highly personal and encouraged playfulness, while using their content knowledge and skills[5]. Due to the positive initial results, teacher resources and lesson plans are now being developed to support this type of learning further in the classroom.

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Child-led Enquiry

Christine Preston, Science specialist teacher and Cassandra McKie, Kindergarten teacher

A Kindergarten student wondered why one of her bouncy balls bounced higher than another. This puzzled the class too. Their classroom teacher suggested they could ask the Science specialist teacher if she could explain it. Together, the children and teacher devised and sent an email.

Introducing the investigation

The lesson commenced by talking about the email and the question: *'Why did one of the balls bounce higher than the other?'*

Next, the teachers showed the children a special ball called an 'off road' ball that is supposed to bounce on just about anything. The children were asked: 'Do you think this ball will bounce well on the carpet?' After they all had a turn feeling the ball, the teacher held it up ready to test how it bounced. She asked: *'How well do you think it will bounce?'*

The teacher held the ball at one of the student's waists and asked: *'If I drop it from her waist, how high do you think the ball will bounce?'* The children watched the drop and observed how the ball rebounded. This action was repeated with ball being dropped from different heights. To conclude this part of the learning experience, the following questions were asked:

'What did you notice about how high the ball bounced depending on the different height?'

'Is there a relationship or pattern?'

'The higher we drop it from, does it bounce higher or lower?'

As there was some confusion as to the answer to this last question, it was decided that the class should conduct an investigation.

Conducting the investigation

The teachers asked the students how they could conduct the experiment, so they were all measuring in the same way. They identified that they could use some wooden blocks to measure the height of the bounce. Each group followed these steps:

Step 1: Hold the ball at the top of an upright block, drop the ball and see how high it bounces. Repeat twice to check if the result is the same.

Step 2: Place two blocks on top of each other. Repeat Step 1.

Step 3: Place another block on top of the first two. Repeat Step 1 again.

Using digital technologies to analyse the results

It was decided to use an iPad to video the bounces and enable informal units of measure to be used. Selected videos were played back to the children. The pause feature helped them see the point where the ball stopped moving upwards (bounce apex). The children then shaded bars to record this on a scaffolded worksheet to show how high the ball bounced.

Assessing children's skills and understanding

The completed worksheet and the videos were used by the teachers to collect information for assessment. Skills in working cooperatively, following procedural steps, making observations and measuring informal measurements were shown in the videos. The girls' ability to record results, look for patterns and use evidence from investigations could be determined from the completed work samples.

Science Pedagogy

By asking open-ended and prompting questions, the teachers encouraged the children to discover the answers themselves, illustrating child-led enquiry. This approach not only empowered the children as knowledge seekers, it built their confidence and competence in doing science.

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This abridged article is reproduced with permission from Australian Science Teachers' Association. The full article may be accessed through: Preston, C & McKie, C (2018). Try this: Child-led inquiry. Teaching Science, 64(3), 5-9.

Now If, What Then

Mary Faith, Director of the Grace Cossington Smith Gallery
and Head of Visual Arts

Stephen Mushin presents problem-based learning activities focused on real world issues that invite students to take on open ended challenges with innovation and a creative mindset. His exhibition Now If What Then displayed 19 digital drawings and a 3D printed sculpture that posed questions exploring art and design, statistics and logistics, science and sustainability, narrative and imagination and ethic and attitudes. At Abbotsleigh these ideas have been investigated by many curriculum areas and a range of ages and have enabled the Grace Cossington Smith Gallery to function as an extra classroom for the School.

Stephen's background training is in industrial design and his passion is ecology and a sustainable future.

In 2011 Stephen was awarded the British Council's Big Green Idea Award for an open-source aquaponics system. This Food Hub Project aims to provide communities in developing countries with a modular farming and composting system combining fish, fruit and vegetable production at commercial scales.

Stephen works with dual intentions – first to design immediate solutions to real world design problems and second to 'intelligently dream' to inspire creative design thinking practices. Now If What Then revealed Stephen's imaginative ideas exploring interactions between man-made machines and the natural world. Each digital drawing is a thought experiment about a zero-emissions machine, supported with the science, mathematics and sketches to explain the functionality and logic of the ideas.

More specifically I'm interested in how we can use humour, satire and outlandish future narratives as positive devices which open our minds to radical and very serious ideas for change.'

The collaboration with Stephen Mushin enabled students to consider creative solutions to challenges of our time. By researching the real life mathematics and science behind each problem, brainstorming creative solutions, then taking this practical data and reimagining the way our world could function, Stephen showed our students how engineering, mathematics, science and the arts can be used to solve real life issues.

Stephen says,
'I'm interested in the power of imagination and the allure of wild new inventions as panaceas for big global problems.'

Kathryn Hunyor (AOG 1986-91) was Head of Creative Programs, at Object: Australian Design Centre. She worked with Stephen as part of the project, CUSP: Designing into the Next Decade. Kathryn then started her own company, Art Waku Waku, and she took Stephen to Japan to exhibit and do a residency in Tokyo. Kathryn curated Now If What Then at the Grace Cossington Smith Gallery.

'Experiencing Stephen Mushin's work is an exercise in suspended disbelief of gigantic proportions. His ideas for addressing myriad earth's environmental challenges are extremely humorous and highly unconventional. Stephen tackles very serious issues in such an outlandish way that we are left wondering, 'Is he serious?'

He is.

When I first came across Stephen's work, my colleagues and I were looking for a designer who was tackling environmental issues, but doing so without the usual earnest, bleak and guilt-ridden rhetoric. We were instantly attracted to Stephen's philosophy, but when we met him in the flesh, he was even funnier and more intense than we had imagined. As we started telling people about his prodigious talent, exuberant energy, and black humour, we adopted the short-hand explanation,

'He's a cross between Dr Seuss, Roald Dahl and a mad professor.'

Unfazed by this description, Stephen often points out that if aliens dropped down to earth right now and saw what we were doing to our environment; burning fossil fuels, generating excessive waste and destroying natural ecosystems, they would think that we were totally insane. And therein lies Stephen's point: is his proposed future really that crazy?

To bring his imagined future-world to life, in 2013 Stephen launched the long-term art project Now If What Then – a series of drawings of would-be, mega ecological machines. Although the product of his wild imagination, these machines are all grounded in very real science, and to varying degrees, theoretically possible. Accompanying each drawing are detailed scientific explanations and complex calculations to illustrate how these machines can address environmental issues. By showing his workings and incorporating workshops and interactive displays into his exhibitions, Stephen is also challenging us. We become active participants in this progressive, stream-of-consciousness line of enquiry.

He wants us to push the boundaries and challenge the status quo. He rewards us for crazy ideas and he judges us only by how big and brave our imaginations are.

But this is not escapism. Stephen's world, although full of fantasy, absurd ideas and wacky-looking machines, is not about fleeing from a harsh or dark reality. It is not a personal, lonely or isolated experience. It is about our whole community developing a stronger sense of ownership and belonging, and collectively making changes in our world. Stephen is all about embracing, with relentless optimism, the reality and the issues of our current lives.

In 2014, one year into the project, nowhere was this optimism more needed than in a country like Japan, where the dangers of nuclear power continue to be keenly felt, and fears for future energy procurement are real. But heated debate around environmental issues and ongoing efforts towards natural-disaster-proofing the country don't easily allow for crazy imaginations and wild creativity. So it was very exciting when a fellow curator at Tokyo's prestigious Spiral Gallery wanted Japanese audiences to have a 'Mushin adventure'. Together Stephen and I worked to develop Japan-specific projects and engage with local communities to understand and respond to the particular issues of their environment. To our delight, Japanese audiences were only temporarily shocked before they threw themselves into the challenges that Stephen posed. Many of the wonderful works inspired by this experience were on display at the Grace Cossington Smith Gallery.

And so it was the Abbotsleigh community's turn to fasten their seatbelts and jump on board for this wonderful adventure, where the final destination all depended on our collective creativity.'

Kathryn Hunyor
Director, Art Waku Waku and AOG,1986-91
www.artwakuwaku.com.au

The Road to Design Thinking

Ishara Gunesekere, Science Integrator

Nothing exists in isolation. Never is this statement truer than when seeking to build a maker education culture where cross pollination of content from multiple disciplines is fundamental to success.

It is equally true that building skills and knowledge in the field of enquiry are essential before engaging in the design thinking process. One cannot exist in isolation to the other if we are to see our girls problem solve and make a positive social impact in STEAM areas.

The following projects illustrate just how discipline boundaries have blurred when skills and knowledge are explicitly taught across domains prior to design thinking methodology being undertaken for young girls from Years 1, 3 and 5.

On a Beam of Light

The popular children's book, *On a Beam of Light: A Story of Albert Einstein*, was used as the catalyst to provoke interest and raise awareness of an icon in the field of scientific thinking and enquiry. While the study of light and sound was a prescribed NSW Education Standards Authority (NESA) unit for Stage 1 (Years 1 and 2) students, the teachers saw this as an opportunity to integrate the learning across multiple subjects including Literature, Music, Technology, Science and Mathematics.

To set the girls up for success, skills and knowledge were progressively built through a series of four half-hour rotations each week over four weeks. Instruction was provided in basic electrical circuitry, coding, sound generation and light refraction. As a springboard activity, a visit to the school's Chapel enabled investigation of the workings of the organ and the impact of light traveling through stained glass windows.

With these skills and knowledge embedded, the girls confidently engaged in the design thinking process. They were asked to design a passion project that included

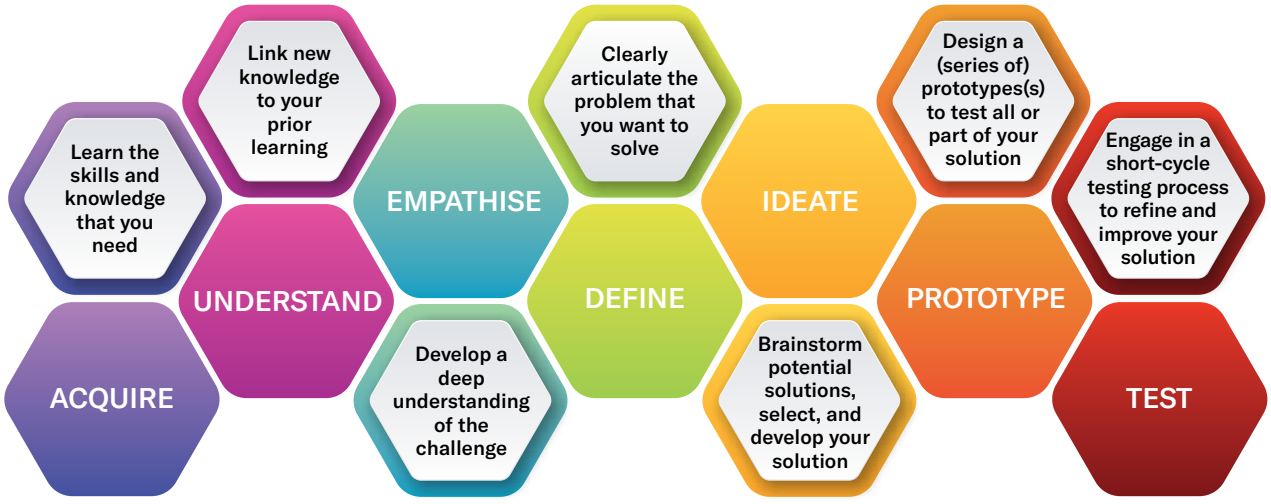

Diagram adapted from Stanford Design School K-6 lab.

light and/or sound. The diversity of responses was impressive. From LED shoelaces and an illuminated tutu to the creation of light boxes and balls, the girls demonstrated their capacity to empathise and respond to a problem, define a solution and solve subsequently arising difficulties before generating a prototype that could be tested and further refined. The girls' solutions were showcased to the entire school community, Pre K-12, at the Abbotsleigh GLOW Festival.

The success of this project was due to the preparedness of the teachers to see these Year 1 girls as capable learners. Equally important were the human resources made available to the class teachers with support from specialists in Music, Technology, Science and pedagogy secured to give input throughout the unit.

Melting Moments

For Year 3 students, the concept of heat energy and the skills of 'fair testing' can be dry and uninviting. With the promise of the opportunity to design, make and test a chocolate melting machine, imaginations were piqued and the reason to acquire skills and knowledge surrounding heat energy became real. The unit investigated states of matter and how adding or removing heat affected the process. Through a series of guided experiments girls learnt the principles of fair testing and how to alter the properties of matter with wax, jelly and chocolate. The roles of heat insulators and conductors were discussed and tested, and the scientific knowledge needed to understand solar energy was explicitly taught.

The scene was then set for the challenge of making a melting machine using only solar power. Contraptions were created, tested and refined to produce the most effective machine capable of melting a square of chocolate in the fastest time, resulting in a successful, scientific design thinking project.

Shake, Rattle and Roll

The Year 5 Curriculum prescribes the study of rapid changes to the earth's surface caused by natural events. This outcome was achieved through an investigation into tectonic plate theory and enabled the integration of Geography, Engineering and Science. Students were taught through a series of hands on experiments how the surface of the earth is altered and how humans have adapted to living with these changes. Emphasis was placed on the phenomenon of earthquakes and the challenge of building earthquake resistant buildings. Students learnt how scientists collect information on earthquakes and how they predict and measure using scales. Base isolation theory and the need for triangulation of built shapes to create rigidity were taught with the help and technical expertise of a parent who is an engineer.

Following the devastating earthquakes in Christchurch, New Zealand, the girls' concern for families who had lost their homes led to another project. Girls were challenged with the task of designing an earthquake resistant building to replace one of those damaged beyond repair. Prototypes were built using marshmallows and toothpicks. Following further refinement, the girls constructed models of an identified building with at least two quake resistant features. Structures were then tested using an earthquake simulator constructed by the School's maintenance team. The building that withstood the most shaking for the longest period was then evaluated to identify the features and attributes enabling such robust resistance.

Building Capacity

The need for content knowledge and skills becomes real to students when practical application in real life scenarios is made available to them. The content is essential only in that it enables skillful responses and deep learning through a design thinking process. This process is enhanced when meaningful links and connections between disciplines are identified and made explicit to the learner. The success of these projects has been due to teachers being ever willing to involve subject experts when stepping beyond their locus of knowledge and experience. Nothing exists in isolation.

STEAM in Service Learning: Year 3's St Lucy's Maker Project

Brittany Black, Year 3 Coordinator

In 2018, Abbotsleigh's Year 3 students collaborated to design and make products that would solve real-world problems relevant to the lives of people they cared about. Grounded in our Service Learning program, the St Lucy's Maker Project was a platform for students to meaningfully combine and apply their understanding of Science, Technology, Engineering, Arts and Mathematics. The project's interdisciplinary nature enabled students to draw on their critical and creative thinking skills as well as prompt deep and sincere student dialogue.

Before considering the St Lucy's Maker Project, it is important to understand the structure of the Year 3 Service Learning unit. It involves the students partnering with children from St Lucy's School, a local school for children with special needs. The driving force behind the Service Learning program is that of reciprocity, and both Abbotsleigh and St Lucy's learners benefit as they build new friendships and a genuine appreciation for the abilities of others. Shared drama and music lessons provide the perfect stage for students to interact, question, cooperate and bond.

The St Lucy's Maker Project was initially inspired by a drive to foster a deeper sense of empathy. Teachers realised that students need an opportunity to put their empathy into action, they need to be empowered to connect selflessly with others. With this in mind, the Year 3 team set out to develop a rich and engaging Maker project that was directly linked to the established Service Learning unit.

The girls were prompted to investigate the needs of the St Lucy's community. They surveyed the teachers at St Lucy's School and found the teachers spent many hours producing specialised instructional social skills videos as well as visual resources for their students.

Armed with a greater appreciation for the needs of the school, the girls set out to design, make and refine social skills videos and visual resources. As they engaged with the design process, they learnt many new and practical skills, particularly within the domain of technology. The girls were split into two groups: the social skills group and the visual resources group. They could nominate which group they preferred; they were not limited by class groupings.

The social skills group was assigned a social concept, such as sharing or safe play. They were then tasked to script and storyboard their video. The process of storyboarding relied on methodology and imagination. Students were also challenged to learn simple sign language as it was important that signing was included in the video. After refining their storyboards and scripts during the rehearsals, the girls underwent an 'IT boot camp' where they learnt elementary videography and editing skills. They then took turns to film scenes, focusing on shots, timing and lighting. Finally, they were expected to polish their videos under the guidance of IT Integrators.

The visual resources group was required to plan and create instruction cards for group games like 'duck, duck, goose' or 'pass the parcel'. To begin, students engaged in a computational thinking exercise whereby they completed a task analysis and broke their game into manageable, directive steps. They designed images and devised appropriate language to illustrate each step. Finally, the girls combined the information into user friendly game cards. In order to create these resources digitally, they had to improve their formatting skills. While students were provided with a basic template, they were still challenged when mastering complex publishing skills.

Throughout the design process, students faced obstacles. In order to overcome these complications, they needed to adopt innovative mindsets and become 'creators of technology, not passive consumers' (Ministry of Education, New Zealand (2019)). Learning was hands-on and disrupted the traditional notion that learning should be led by the educator. In the words of a Year 3 Abbotsleigh student, 'my learning felt important because it was more than just writing in my book and our team had to make careful choices. Sometimes we had to change our thinking.' By marrying the scientific skills of enquiry, the art of expression and original design and all manner of technical skills, the Maker project elicited students' bold attitudes towards problem solving.

As an aside to the Maker project, Abbotsleigh girls also ran a fundraiser in the form of a fresh fruit festival, fondly known as 'Abbfresh'. The funds raised went towards enriching the learning of students at St Lucy's. This element of our St Lucy's program required careful budgeting, marketing, invention and relied heavily on learners' mathematical knowledge.

The St Lucy's Maker Project demonstrates that Service Learning and the STEAM movement can be united and see valuable outcomes for students across multiple learning disciplines. The successful delivery of the project promotes the notion that STEAM-based learning can lead to more authentic social-emotional connections, student ingenuity and open the door to inspired teaching and learning for all.

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Digital Leaders

Jon Adams, IT Integrator

New technologies have changed almost every aspect of modern life. Students in Kindergarten this year will be graduating from Abbotsleigh in the year 2031 and it is vital that we prepare them to face the ever-changing technological world that will meet them.

Technological advances, widespread access to the Internet and the proliferation of connected devices are facilitating new educational approaches that go beyond the traditional face-to-face classroom setting. Due to the demands and time constraints of classroom teachers, they are often unaware of technologies that could assist their teaching aims and prepare these students for the future. The role of the IT Integrator at Abbotsleigh is to support teachers to engage students in dynamic and creative technology rich projects and investigate new software and hardware solutions and processes to facilitate student learning. Given that all students in the Junior School are technological natives rather than immigrants, it was almost intuitive to create a club that would allow these technologically savvy students to support their teachers and fellow classmates.

Digital Leaders is a program for students interested in leveraging digital as well as helping others to learn to use the School's technologies. Students from Years 3 to 6 commit to the program by attending Technology workshops to obtain skills in a specific technology (eg, SMART Boards, coding, drones and e-safety).

Digital Leaders embed their leadership by assisting teachers in the setting up and troubleshooting of technology, by mentoring students and being knowledgeable hosts for important visitors. Last year's Digital Leaders, who are now in the Senior School, have been called upon on many occasions to support and facilitate Abbotsleigh's Bring Your Own Device (BYOD) program. Educating these Digital Leaders on how technology can be used to enhance their learning can then be transferred back to the classroom and support the learning outcomes of the teachers.

"Technological Pedagogical Content Knowledge" (TPACK) model emphasises that a deep understanding of how technology can be used to enhance their students' learning is as essential for teachers as knowledge of their subject area and different pedagogical approaches. From the literature it becomes clear that for technology enhanced learning to have a wide-spread impact teachers must be fully engaged in its use, and that using their existing practice as the engine of change could be a key. (Glover, Hepplestone, Parkin, Rodger & Irwin, 2016)

SMART Boards in the Classroom

Our Term 1 focus in the Digital Leaders program has been upskilling the students to be expert users of the SMART Boards. These interactive white boards (IWB) combine the functionality of a white board, computer and projector into a single system that uses touch control to perform all mouse and keyboard functions. Due to their collaborative natures, IWBs are highly effective for whole group instruction, active discussion and questioning (Preston & Mowbray, 2008). With the recent addition of SMART Learning Suite Online, teachers can now gain valuable insights with real-time formative assessments and foster student co-creation in collaborative workspaces. Showcasing this powerful tool to our Digital Leaders can then be transferred back to the classroom.

e-Safety

Our Term 2 focus in the Digital Leaders program will be addressing the 21st century skill of digital citizenship. This is essential to help students to learn, communicate and collaborate safely and responsibly in the online world. During these sessions, the Digital Leaders will be exploring the concepts of Internet Safety, Privacy and Security in addition to Digital Footprint.

What can Digital Leaders do?

- Support staff and students with the use of technology
- Promote e-safety
- Trial and evaluate new equipment and services
- Improve their understanding of technology
- Share their knowledge and skills with others
- Act as e-ambassadors
- Provide in-class support to teachers
- Engage in global collaboration with other Digital Leaders

In the future

Abbotsleigh Junior School has made a considerable investment in technology, from 6000 Series SMART Boards across the school, 1:1 laptops, iPads and 3D printers. However, staff and student skills, and more importantly their confidence, are sometimes inconsistent. In order to encourage and support the innovative practice of technology-enhanced learning in addition to up-skilling our students to be confident users of technology, the Abbotsleigh Junior School Digital Leaders Program has been established.

In the next phase of this program we hope the current group of Digital Leaders will present to fellow students on specific topics regarding technology, create a shortlist and manage the training of certain software and research and suggest new technologies that can enhance their learning.

'There are only so many hours in a classroom teacher's day. We must step back and facilitate. It is more effective to upskill Digital Leaders who can better support teachers and other students when needs arise.'
(Jeanine Kobylinski, Abbotsleigh IT Integrator)

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Scratch

David Knott ICT Integrator and Murray Keating, Year 4 Coordinator

When learning about British colonisation of Australia in 1788, Year 4 students studied the journey of the First Fleet in terms of significant dates, distance travelled and route taken.

To enhance cross-curricular learning outcomes, it was decided to use Scratch, a block programming tool developed by the Massachusetts Institute of Technology, to plot the route of the First Fleet's journey.

Using Scratch, the students created an animation in which a ship travelled from Portsmouth to Botany Bay in a series of pre-programmed stages. In addition, text was displayed at the start and end point of each stage. Drawing on historical and geographical knowledge, students were required to use their coding skills to plot each leg of the journey. Regular reference to world maps was made to ensure the coding of coordinates was accurate.

At the beginning of this unit, students were introduced to the concept of abstraction, where the entire journey was broken down into manageable steps and stages.

Students could then decide on an algorithm (sequence of steps) that would describe the first stage of the journey. Once developed and tested, the same algorithm was copied and pasted. Finally, modifications were made to the coding sequence to describe each subsequent stage.

When using Scratch, the students were challenged to determine which coordinates should be used for the start and end point of each stage. Furthermore, they needed to adjust the time that the animated ship took for each part of the journey.

This program also helped develop additional skills such as strategic thinking, troubleshooting and the use of coordinates on a cartesian plane. Overall, the use of Scratch to develop important coding skills while learning more about the journey of the First Fleet, was most beneficial.

Gender Gap Assault in STEAM for Abbotsleigh Girls

Sally Ruston, Head of Junior School

Why is it that girls are so poorly represented in the STEAM domains?[1] This is a perplexing problem and one that has seriously deleterious effects on our society when up to 50% of our population is not able to share in thought generation and solution finding to world problems. Given it is now widely accepted that cognitive capacity does not differ between the sexes, it is up to educators to then review what environmental factors and cultural bias exist that privilege male access to careers in STEAM.

Surely a girls' school is ideally placed to create the optimal learning environment that isn't impacted negatively by bias. At Abbotsleigh Junior School the quest began in 2010 when trying to understand why our girls in Years 3 and 5 in National Assessment Planning – Literacy and Numeracy (NAPLAN) testing performed poorly in numeracy when compared to literacy outcomes. While the data shared here shows that the phenomena was not peculiar to our school, and our results when compared with State averages are exceptionally good, we felt that action needed to be taken.

Year 3	Abbotsleigh Yr 3 Top Band % in Reading	State Yr 3 Top Band % in Reading	Abbotsleigh Yr 3 Top Band % in Numeracy	State Yr 3 Top Band % in Numeracy
2010	63%	28%	31%	22%

Year 5	Abbotsleigh Yr 5 Top Band % in Reading	State Yr 5 Top Band % in Reading	Abbotsleigh Yr 5 Top Band % in Numeracy	State Yr 5 Top Band % in Numeracy
2010	62%	17%	40%	21%

When determined to drive change, it is my belief that a single action rarely creates the desired effect. In fact, I would argue that at least four initiatives need to be undertaken to see change attained. To that end in 2010 we sought to change the way we viewed and taught Mathematics with the following initiatives:

- **Increased Teaching Time for Mathematics:** While we certainly ensured our girls met the regulatory authorised minimum time for course delivery in Mathematics of 4.5 hours per week, we accepted the research that pointed to 'time on task' being a strong predictor of outcome. Thus, it was in 2011 that we added an additional hour of Mathematics lesson time to the timetable for all students from Kindergarten to Year 6.
- **Professional Learning in Mathematics:** Given that John Hattie's meta- analysis clearly states that teacher quality (effect size of 0.44 – where any measure above 0.4 is desirable) and teacher professional learning (effect size of 0.62) are well correlated with enhanced student learning outcomes[2], a program of professional learning in Mathematics was mapped out and delivered. Emphasis was given to building teacher capacity in delivery of programs that focused on fluency and concept building to the point of mastery, as well as explicit teaching of the range of problem-solving skills that enabled syntheses and success with real life mathematical challenges.
- **Analysis of Data:** We are fortunate to have a Mathematics specialist teacher in our primary school, whose passion and expertise in this field exceeds that of typical classroom teacher. This educator was well placed to analyse both NAPLAN and competition data to drill down and identify areas of comparative weakness. We found that girls were strong in number, yet their ability to respond to spatial questions was inferior. Further research into this phenomenon revealed that while girls are as cognitively able as boys, there is strong evidence that they are weaker in their spatial ability.[3] Thus, we went about changing the physical environment to provoke spatial play.

- **Games and Scootering Introduced:** In 2010 a major multimillion- dollar build was completed. The result was the establishment of wide undercover and outdoor pathways. While not the original intent, it became evident that these spaces could lend themselves well to active play. Yet how were we to provoke interest in the girls who in the main enjoyed nurture and passive play over games that would build their spatial awareness? Initially we introduced lots of large-scale board games with giant chess and drafts pieces, blocks and sporting equipment. All were set up each morning in play areas. The girls responded positively and were regularly seen engaging in more robust play. Yet it was when our oldest girls wanted to bring their laptops to the playground that I realised we were losing the battle. I had read of schools in New Zealand who were introducing bike riding after establishing bike and fitness tracks. I knew that we didn't have the land or space for such an undertaking but did see that scooters could have a place.

Thus, it was after much risk assessing, discussions with staff and girls, the setting of protocols, the introduction of a new playground scooter duty and approval seeking, that we allowed and actively encouraged the girls to bring and ride their scooters at school during break times. This was an immediate success and the take up rate was huge. The benefits included girls learning how to measure and take risks. Speed had to be managed, balance had to be attained, coordination was essential and slowly spatial awareness skills grew. So coincidentally did social cohesion and fitness.

We know we have been successful in raising the profile, attitude and success rates in Mathematics. Our 2018 NAPLAN results show how we have markedly closed the literacy/numeracy gap and enhanced the girls' achievements overall in Mathematics. Growth from 31% to 70% in the percentage of girls in the top band in Mathematics in Year 3 is certainly something to celebrate.

Year 3	Abbotsleigh Yr 3 Top Band % in Reading	State Yr 3 Top Band % in Reading	Abbotsleigh Yr 3 Top Band % in Numeracy	State Yr 3 Top Band % in Numeracy
2018	78%	31%	71%	20%

Year 5	Abbotsleigh Yr 5 Top Band % in Reading	State Yr 5 Top Band % in Reading	Abbotsleigh Yr 5 Top Band % in Numeracy	State Yr 5 Top Band % in Numeracy
2018	50%	19%	56%	14%

While this article has focused on growing girls' competence and confidence in Mathematics, we have used a similar methodology to increase capacity and aptitude for science, technology and engineering. See the article in this journal, 'Space to Think' on the creation of spaces to support our girls' learning in STEAM to hear more of how we have collaborated to bring integrated learning opportunities to the girls that remain disciplined and rigorous while also being highly engaging. I share the following data that highlights how over time we have been able to do our part in growing interest and capacity for success in STEAM. The following information relates to our Year 12 student cohort of 150 and their increased university course uptake in engineering.

Higher School Certificate Year	2013	2014	2015	2016	2017	2018
Student numbers undertaking university undergraduate courses in engineering	2	4	6	11	10	10

Conclusion

The argument and assault are not ones of gender. Rather it is finding the will and the means to deal with weaknesses in process, environment and mindset that have enabled us to do our part in growing girls with capacity and enthusiasm to engage in the intellectual pursuits of STEAM based learning.

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STEAM as a Deep Thinking Tool in Early Learning

Marian Doull and Caroline Surendra, Early Learning Educators

"STEAM is an educational approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student enquiry, dialogue, and critical thinking. The end results are students who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process. These are the innovators, educators, leaders, and learners of the 21st century!" Education Closet (2019)

At Abbotsleigh's Early Learning Centre we draw on research from the Reggio Emilia philosophy and principles of STEAM to develop deep learning. We believe that STEAM learning starts early. While how we teach newborn babies will differ from the approaches adopted with our four- to five-year-olds, what remains constant is our determination to ensure learning is rich and deep covering Science, Technology, Engineering, the Arts and Mathematics.

With STEAM principles in mind, the Early Learning Centre set up a Maker Space early in 2016. Our initial vision was for it to be a place where children learn in an environment where risks are taken, mistakes are celebrated and challenges are embraced. We see the space as providing opportunities for small, personal interactions and conversations, as well as larger collaborations. What could be deemed of little consequence in the day of a young learner is transformed, with teacher facilitation, to a time of rich investigation and cognition.

Teacher Generated STEAM Provocations

Our STEAM journey began with teachers setting formal provocations to provide opportunities for children to engage across the disciplines. A common exploration for children is the scientific concept of buoyancy and often a water tray is filled with different objects that children can test with regards to flotation. Using a STEAM lens to deepen this experimentation, we asked the children, "How can the dolly with the broken leg get across the water?" Immediately the children became engaged, posing a range of solutions.

"A bridge!"

"A life jacket!"

"Let's make a boat, that's a much better idea."

"Let's make a really pretty boat for the little girl."

We had placed the water tray in the Maker Space, so the children could access the materials they needed to design and create. Simple objects such as yoghurt pots and tape were engineered into structures that were buoyant, and not so buoyant. Some prototypes failed the children's rigorous testing regime and poor dolly spent more time in the water than crossing it. Intense observation and conversation took place to inform design modifications. Teachers only intervened with questions to move the thinking forward.

After much collaboration, experimentation and deep thinking, success was achieved. A beautiful boat that stayed afloat and allowed dolly to reach her destination was created. The children even tested different weather conditions by blowing on the boat and rocking the water tray to create waves. The depth of enquiry, persistence and engagement were enhanced by setting the provocation within the narrative of the dolly that captured imaginations and gave purpose.

Through the online communication platform Storypark, parents accessed their children's learning and continued conversations at home.

STEAM has provided an invaluable tool for us to make the learning of our youngest members visible to our extended community. No longer do they see a mishmash of tape and yoghurt pots, but a finely designed and crafted vessel capable of making safe journeys across an exciting sea.

Asking STEAM Questions of Children –

Rather than ask **'why**', ask **'what'**:

- What happened there?
- What did you try?
- What did you notice when...?
- What do you think will happen if...?

Child Generated STEAM Provocations

Children are also open to pursuing less formal provocations involving STEAM. One of these seemingly inconsequential learning experiences began when one of the teachers asked a group of children, aged three to four, if they knew where her water bottle was. Usually this would be quickly dealt with, but having experienced STEAM projects, the children began a complex hunt for the bottle. Four of them started to discuss and argue about where it could be.

They went outside and wandered around the garden asking other children if they had seen the bottle. One of them suggested that it may be up in one of the trees. "No. It's too heavy to be in a tree. It would just fall out of the branches," another commented (Science). One of them thought that it may be on the roof of the shed. *"We need a ladder to get up and see if it is there,"* he suggested (Engineering). *"And maybe get the camera to take a photo of the roof too," another added (Technology). One of the children started to draw a picture of the red bottle to show to other children in the playground, "So everyone knows what it looks like,"* he said (Art). Together they worked out that if they got a ladder it would need to be high enough to get right to the top of the roof. "*Maybe it would need 20 steps.*" (Mathematics).

Their elaborate hunt went on for 20 minutes, each of the four making suggestions as to where the bottle could be. Their thinking was deep and meaningful. They explored different hypotheses and questioned each other's answers. Importantly, they persevered with their mission. Eventually the bottle was found and was proudly presented to the teacher.

When the teacher reflected on this brief exchange, it became apparent to her that she often missed these small moments. What these children had just shown her was that even in the hunt for the water bottle, great learning was occurring. The core principles of STEAM were very evident. The thinking of all four children was deep, the connectedness between them was obvious and the character of each child was brought forward as they worked as a unit.

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Education Closet (2019) https://educationcloset.com/steam/what-is-steam/

The Making of Izzy Innovate

Sally Ruston, Head of Junior School, and Donna Moffatt, Director of Learning Innovation

The *You Can Do It!* program, values and character strengths are fully embedded in the Junior School. Whether puppets or life-sized keys are used as age appropriate reminders, the girls know the importance of emulating these enabling behaviours: affability, confidence, organisation, persistence and resilience.

While this program, supporting the social and emotional wellbeing of our students, has been used for nearly 20 years, we were fascinated when the girls suggested that a new key and puppet be included to reflect the importance of innovation. This suggestion came through our Student Representative Council as we opened STEM Street. Thus, it was to this group we returned to ask more about what such a puppet should be named, what language would be associated with it and what it should look like. We were delighted when the girls named the female character Izzy Innovate, defined her key phrases and decided that she must wear blue overalls and have messy hair with a pencil behind her ear. She should wear a lab coat and a tool belt. Our girls were realising just how important a skill it was to be prepared to take risks and seek enhanced solutions through trying again.

Creating the life-sized key turned out to be the easy part. However, we were stumped as to how were we going to create the puppet to meet such a specific brief. An idea from left field saw us approach one of our cleaners – Dave London, who has passion and skill in sewing and tailoring. With the brief in hand, Dave took up the challenge. He openly confessed that he had never made a puppet before but was keen to give the project a try. The puppet making journey started with internet researches, online tutorials and seeking advice from experts in the field. Copyright issues were navigated until Dave finally came up with an original puppet design. The entire process included many false starts, prototype failures and the need for reworking of initial ideas to create a puppet that not only matched the girls' description but would be durable and practical. Creating a flexible head in which a hand could operate the mouth was the trickiest part of the process. Dressing Izzy and attaching tool belt, goggles and helmet were fun, final steps.

When asked what had been learnt in the process that would be a good message for the girls, Dave commented, 'Experiment, be creative and if it doesn't seem right, try again. Do research, ask for help and be ready to think outside the box.' Dave was proud of the final product, recognised that he had learnt new skills in an area of great personal passion along the way and was thrilled with the positive feedback that he received from colleagues and students.

Izzy Innovate is a very welcome addition. She makes a visible statement that girls can design, construct and tinker to create and innovate. Using tools, wearing overalls, recognising FAIL – First Attempts in Learning – and persisting to see projects to completion are the healthy messages that Izzy conveys to our girls.

IZZY LANGUAGE

- Mistakes are what we learn from
- There's always another way
- I'm inventive and like to improve ideas
- If you dream it you can create it


Innovate

Year 4 Girls in The Shark Tank

Dani Salt, Year 4 classroom teacher

Change is the constant in our girls' future world. Success will be achieved by those who are agile in their thinking with the ability to be empathic and use logic to solve yet unknown challenges.

How then are such skills and mindsets taught in a primary school?

We have harnessed the skills of entrepreneurship with our girls in Year 4 as a means of responding to the challenge of not doing 'what you always did'. The Shark Tank Innovation and Invention Pilot Project was introduced to a single class of students in 2017. After establishing links with NSW Education Standards Authority (NESA) outcomes in Mathematics, English and Science and Technology, the program was brought to life with an aim to develop creativity, curiosity and a passion for developing ideas.

'If you always do what you always did, you will always get what you always got.'

- Albert Einstein

The pilot program well met the required integrated NESA outcomes, so in 2018 the 'Shark Tank' was introduced to all Year 4 students. Just as the girls' projects were iterative in nature, so too is this unit of enquiry. The second year saw the introduction of the concept of empathy. One criticism that can be leveled at the entrepreneur mindset is the selfish focus that can eventuate. Thus, the second iteration encouraged girls to work collaboratively in small teams to design a portable product for a specific audience. While such structure ensured that the girls' design solutions were outwardly focused, these constraints also limited creativity. In 2020 the project will only ask the girls to solve a problem for a target audience.

Students began by learning about modern day inventors as well as the skills needed to become a successful entrepreneur. The exciting new undertaking focused on the design process. Opportunity was provided to research the market and develop an idea into a prototype. Materials were tested and the girls used a range of hand held tools to create a product that responded to an area of passion. Reflection and further refinement occurred as girls were required to record ideas, progress and feedback in a journal. The girls astounded educators with the levels of purposeful engagement and independence shown. The open-ended nature of the project meant that a diverse set of 26 different products was created using the facilities of the Curiosity Lab in our newly opened STEM Street.

In the final stages of Shark Tank, a panel of teachers including IT Integrators, Science and Mathematics specialist teachers and Heads of Schools was formed to evaluate and assess the problem-solving skills of the girls while they present their prototype using technology and a written, persuasive speech. Costs, profits and possible losses were also discussed during this time. Several products were 'invested in' and each girl received an evaluative rubric providing feedback from 'the sharks'. This year, the students will display their prototypes and sell their products at a parent evening.

This project has been successful in capturing imaginations and building 21st century skills, while covering off multiple subject outcomes. The entrepreneurship methodology has been a very useful vehicle in scaffolding learning that has seen passions ignited, purposeful engagement enabled and deep learning attained.


School Street
Main Street
Parkside Boulevard
Washington Street
Riverside Park
Blue Lake
Blue Lake Drive
Church Street
Winding Lane
Yolanda June
1
4
5
6
7
8
9
11
12
A
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Making the Maths Count

Sally Southan, Mathematics specialist teacher

Long before STEAM became part of the educational vernacular, Mathematics and Science were a natural, and indeed unavoidable, fit. After all, there is very little Science that can be done without measuring, collecting data and identifying patterns. In a primary school, in which the class teacher is often teaching most, if not all, subjects, the drive to combine disciplines is not new. What is relatively new is the notion that Science and Mathematics should be taught alongside Technology and Engineering from a young age. At Abbotsleigh, these disciplines are often integrated through enquiry-based projects.

As a Mathematics specialist teacher, I am interested in the reciprocal role that Mathematics and the other STEAM fields play in student learning. According to Tytler (2019), the Mathematics often 'grows out of the investigation as a need for quantification, or articulation of spatial thinking' (p. 39). While finding an authentic use for Mathematics is admirable, the need for it does not guarantee that new learning will actually occur. Indeed, one of the greatest challenges is ensuring that, in addition to enhanced engagement, there is evidence of enhanced outcomes. For this reason, at Abbotsleigh the Mathematics specialist teachers and class teachers carefully plan and sequence the teaching that will take place throughout the project.

Our youngest learners, aged five to eight years, regularly initiate research in some or all of the STEAM fields. The class teacher expertly shapes student questions into investigations that are structured just enough to allow students to experience the learning and joy that come from both failure and success. Investigations have included designing and building a Teddy Bear Hotel and planning and creating a town. From the students' perspective, they were learning about measurement, tessellations, statistics, money, spatial awareness and design because they needed these skills in order to achieve their goal.

Levels of engagement were incredibly high and the hands-on nature of the tasks meant that misunderstandings were immediately obvious to the students. Students were self-motivated to correct and improve their own work.

When the Year 4 students expressed a concern over the amount of rubbish they had noticed in the bins, we began an investigation into measuring and reducing the amount of waste created in the School. They had to come up with a reliable method for measuring the rubbish, which involved the testing and comparison of several devices. The students applied a scientific practice by designing and implementing a fair test. Lessons targeted measuring in kilograms, converting measurements, understanding the value of decimal numbers, recording data, calculating averages and representing their findings.

Each of these investigations incorporates varying combinations of the STEAM disciplines. What they all have in common is that the class teachers choose the optimum time to teach and to make student learning both visible and assessible. In addition to the measurable academic outcomes, students develop the ability to manage projects, to work with others and to refine their work. One profound benefit of STEAM education is that Science, Technology and Engineering practices, such as using a design cycle, have increased our students' capacity to work mathematically. The incredible class teachers continually rise to the challenge of balancing the – at times – competing agendas of following student curiosity while still giving them the levels of expertise needed for ongoing engagement in Mathematics.

Tytler, R. (2019). The Challenge of STEM. Education Matters Primary, (Mar-May).

Using School Data to Excel

Kate Coventry, Deputy Head of Junior School

We do not always notice, but we are surrounded by data. In our everyday lives, we frequently gather data and information to make decisions. Corporations do likewise; they constantly collect information from consumers to inform their strategic direction – be it through Google hits, social media activity, surveys or by analysing sales trends.

So how do we teach data in a practical and meaningful way to hook our students and develop their critical thinking skills? The key is to start small and within the school environment, where students have a common contextual understanding.

One example of this was an investigation conducted by a Year 6 class to ascertain how well students were wearing their school uniform. The girls diligently divided and conquered by taking ownership of specific classes within the School. They discretely collected daily data (mornings and afternoons), checking for hair ribbons and that school ties were buttoned up correctly. A spreadsheet was populated with all collected data and students were taught how to format, use basic formulas and create graphs within Microsoft Excel.

The analysis of the results formed a critical component of the investigation with girls asked to look at the 'why' behind the data. For example, a class had a high number of 'offending' students whose school ties were not buttoned up correctly on a specific afternoon. Did that class have sport during the day and were the girls dishevelled because they had a uniform change?

Or perhaps it was comparing morning and afternoon data to see if there was a trend that by the end of a school day it was natural to expect students looking untidy after an active lunchtime. The girls took great delight in sharing their findings in Primary Assembly.

Another investigation by Year 5 girls reviewed the School's house points system. The class wanted to better understand the process of calculating the winning house. House points data from each class was recorded in Microsoft Excel to enable efficient analysis. This investigation raised many valuable teaching opportunities to develop the girls' critical thinking skills. Are total scores used to identify the winning house? Would the results be different if we calculated the average student score per house? Are some teachers more generous than others in awarding house points? Would this have an impact on results?

Based on their investigation, the students were able to make recommendations on how we could improve our house points system. Of course, because each student belongs to a house, all girls were absolutely invested in this project and they felt very passionate about ensuring the house points system was authentic!

While it can be daunting to navigate the unknown of an investigation, it is these types of learning opportunities that motivate and stick with students. Analysing in-school data is the perfect platform for building the foundations of critical thinking in preparation for the wider world.

A Riot of Light, Colour and Sound

Louise Keyter, Visual Arts teacher and Stephan Kooper,
Head of Junior School Music

Can Art, Music, Science and Technology find intersection in student learning? Some may argue that the four are not comfortable bedfellows, yet the work of our Year 6 girls as they created an electronic textile artwork inclusive of a LED feature and set to self-composed music accessed through a QR code, demonstrated such integration is possible. Not only was this possible, but the assimilation of so many outcomes from diverse domains meant that the nature of the learning was deep, iterative and highly successful.

The girls were asked to create a textile design using felt and with a signature LED feature. In the project, light could be used metaphorically, allowing girls to move away from just a literal interpretation. A light used to illuminate a candle was deemed a shallow response. A light used to create a halo effect of hope saw a much deeper interpretation of the theme. Skills in stitching, threading and how to combine light and music into an artwork were progressively taught and developed. Equally important was the development of skills in how to set up a circuit and then embed this within the textile artwork.

This project was successful in its first iteration with the girls gaining an extensive skill set and being very proud of their end product. Yet, upon reflection, a project that highlights light and sound as creative elements would be even more engaging and challenging as increased depth of learning and enterprise were demanded. This enabled the girls to produce a work of art that required an emotive response using both visual and auditory senses.

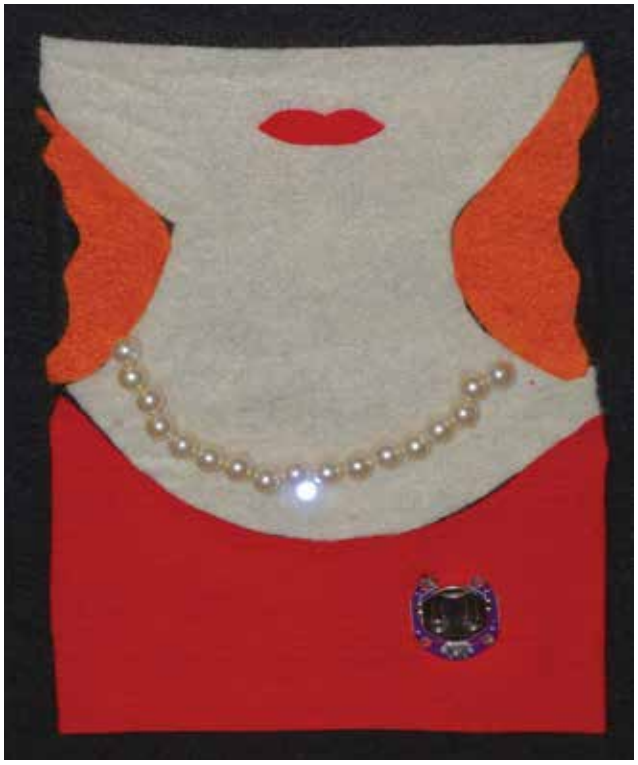
Thus in 2018, our collaboration saw this project shift gears to a new level. The textile and light components were re-imagined to encourage the girls to use light as a focus that would be further enhanced through the inclusion of sound. In Music lessons the power of music in evoking an emotional response was explored. The girls were given a broad range of instrument options including iPad apps and personal and school instruments. They were encouraged to use instruments in an unusual way and to explore music programs such as Audacity to create sound effects.

Focus was given to develop extended percussive techniques and to build understanding of the musical elements including timbre, pitch, pace, dynamics and texture. Again, the emphasis was on using metaphor in music; rather than literal effects. Once the soundscape was recorded, support from the IT Integrators allowed the musical composition to be accessed while viewing the artwork using a QR code.

We were both intent on helping the girls understand that music and art go beyond just their essential concrete skills and that works need to evoke emotion and point to the broader metaphor inherent in each domain. As shared by Greg Lake,

'Music is an emotional experience, and that is what imprints itself on the soul. And any great art is art which communicates human emotion.'

When Science and Technology are used to facilitate such an emotional response in the minds and hearts of 11-year-old girls, we see education fulfilling its brief.



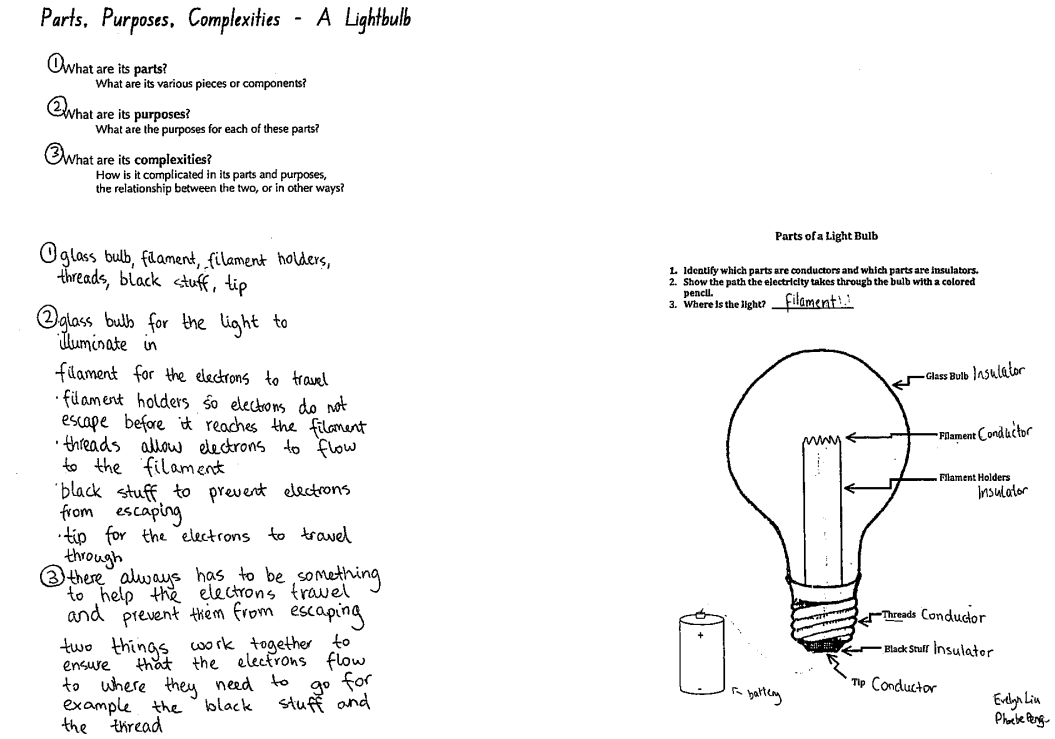


Figure 1 Parts Purposes and Complexities Thinking Routine

Figure 1

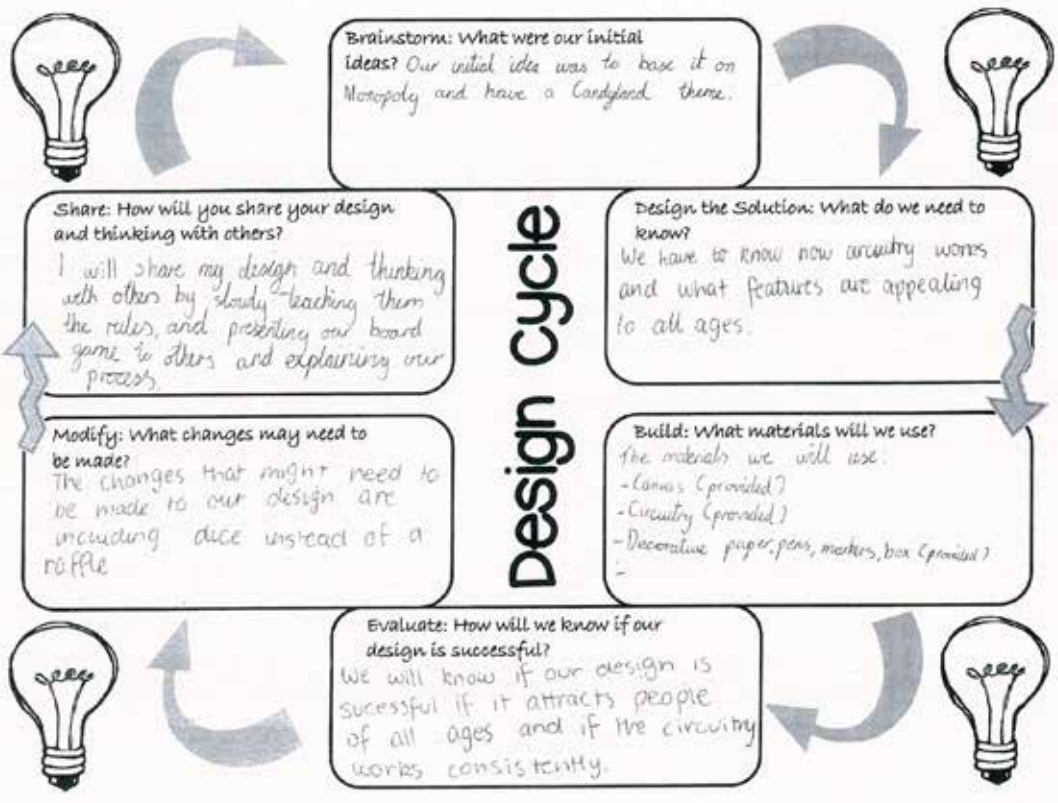


Figure 2

Spin and Win: Electronic Board Games Bring Maker-Centred Learning to Year 6

Susanna Matters, Year 6 Coordinator

Childhood memories often involve families and friends gathering around a table to delight in the simple joys of a quality board game. To complement their study of electricity and light in Science, Year 6 girls were challenged to bring an electronic component to their own design of a board game over the course of a semester.

The design brief was as follows:

You are a board game manufacturer and you have been assigned the task of creating a board game. Your board game must incorporate an electrical circuit somewhere in the design. The game must also include your knowledge of electricity. The game should be original, scientifically accurate, entertaining and educational.

Maker-Centred Learning

Maker-centred learning, with its focus on tinkering, systems literacy and the design cycle, leant itself readily to this project. According to researchers at Harvard University, there are both primary and secondary benefits to maker-centred learning. These benefits include finding opportunities to make things that are meaningful to oneself and the community, building confidence, developing discipline specific knowledge and skills, and furthering one's capacity for critical and creative thinking (Clapp, Ross, Ryan & Tishman, 2017).

Prior to the commencement of the board game project, thinking routines and whole-class discussions were used by classroom teachers to enhance the girls' understanding of systems and sensitivity to the design cycle. The students were asked to individually define the processes of making, designing and evaluating so they became more self-aware of the skills involved in each process. The Parts, Purposes and Complexities routine (Figure 1) was applied to a light bulb so students developed their ability to visualise and articulate the components of a simple circuit and the way they interact with each other. This understanding allowed students to be more intentional in the planning stages of the project.

The Process

The girls commenced this project by brainstorming the features of board games – from playing pieces and strategies to packaging, time constraints and target audiences.

They drew mindmaps and diagrams as part of their planning documentation and organised checklists of required materials. Subsequently, the students had exploratory time to work with circuitry components to decide whether a light bulb, spinner or buzzer would best suit the objective of their game, and to consider whether a simple or parallel circuit would be required. At this stage in the project, the girls completed a design cycle template (Figure 2) to ensure that time for questioning, modifying, evaluating and reviewing had been allocated and to nurture the understanding that these stages are integral to creating.

The Final Product

After an extensive peer review process, the final electronic board games were presented to the school community at GLOW – Abbotsleigh's annual light festival. The girls set up their games alongside photos documenting the making process. There was a clear buzz of excitement in the room as a semester of hard work was enjoyed by all. With its focus on empowering learners, sharing is an integral part of maker-centred learning (Clapp et al., 2017)

Next Steps

At the conclusion of the board game project, key staff members came together to discuss its merits and how it could be further improved. It was decided that the collaborative nature of the project had worked well and that it had allowed authentic use of the design cycle. To further enhance the application of the girls' knowledge of electricity, it was suggested that access to more wires was provided so that the girls could create more elaborate parallel circuits featuring a number of lights, spinners and buzzers. Staff also reflected on the value of self-discovery and the need to give students sufficient time to experiment.

The Year 6 students took great delight in displaying their finished products in our innovative Curiosity Lab and receiving feedback from younger students who are already counting the days until it's their turn to design the next worldwide gaming phenomenon!

Reference

Clapp, E, Ross, J, O'Ryan, J and Tishman, S (2017). Maker Centred Learning: Empowering Young People to Shape their Worlds. San Francisco: Jossey-Bass

Passion, Purpose and Play: How Do We Develop a Culture of Creativity and Playful Engagement?

Donna Moffatt, Director of Learning Innovation

Throughout time, educators, philosophers and psychiatrists have placed a high priority on play. Vygotsky talks about how play creates a zone of proximal development for the child, where the child always behaves beyond his average age, above his daily behaviour. Csikszentmihalyi (1991) emphasises that play is not a frivolous waste of time. When children are deeply involved in play they are learning. Their passion, flow and sense of timelessness mirror the actions of the tinkerer. Both Jung and Maslow view play as an essential component of creativity and, given the increased emphasis on developing creativity, it follows that students should be given regular opportunities to play with ideas.

In fact, in our now volatile, uncertain and ambiguous society, academics, business and the OECD all agree that students need to develop stronger social-emotional skills and that while we are talking about 21st century skills, these skills are not new to the 21st century. They are newly important. In both the classroom and the workforce, social-emotional skills are centre stage alongside content and cognitive skills.

So, it becomes incumbent upon educators to look for ways in which we can promote such skills as creativity, curiosity and collaboration as an everyday part of our classrooms. For our early learning teachers, such planning is second nature to them. However, for many others, they need to reconnect with play, to look beyond the content of their specific subject area to the skills, teaching practices and processes that unite us all as educators. With this in mind, we planned three separate professional learning days, all of them focused on showcasing the teaching practices in our school and community that embody creativity and playful engagement through STEAM-based activities.

For the first of these days, all teaching staff were involved in workshops that replicated our students' experiences, including: an archaeological dig; coding a dance routine using Robotics; using laser cutters in design; app design and game creation; and creating an art installation to depict the collection of mathematical data and its analysis. As a result of this full day of professional learning, many staff came to understand the nature and range of projects that were already being undertaken by our students and the higher order thinking that is involved in such projects. The feedback was overwhelmingly positive, so much so that we ran another of these workshop-based days a year later. This time we focused every workshop around a theme of maker-centred

education and included such experiences as: creating a staff art installation for a festival of light using an Eggbot; dancing with droids; creating a multimedia digital video to explore character; photographic light painting; Virtual Immersive Built Environments (Minecraft); and the ethical dilemmas of turning spaghetti into bridges.

In between these two workshop days, we invited Dr Jordan Nguyen to address our staff. Dr Nguyen is an internationally renowned engineer for humanity. His design thinking starts with empathy and a desire to understand the needs of others, and his belief is that each life has the capacity to improve many others. Jordan creates futuristic and inclusive technologies to improve the lives of people with disability. The range of his work includes biomedical technology, artificial intelligence, robotics, empathetic and human-centred design, and virtual and augmented reality. While Dr Nguyen shared much during his day with us, many staff were most impacted when he spoke about how he employs staff. When interviewing engineers, Dr Nguyen focuses on passion, purpose and the type of learner sitting before him. He believes that he can teach his employees many of the engineering skills but he does not have sufficient time to teach them to be collaborative or creative or analytical in their thinking. These key dispositions must be deeply ingrained in his team members' approach to thinking and leaning.

Again and again, learners are confronted with images encouraging them to play with ideas, to have the passion to explore concepts deeply and to be purposeful in their mastery of skills. Even at the Sydney Royal Easter Show in the Farm of the Future pavilion, the importance of play was emphasised in developing confidence, curiosity, collaboration, creativity and a can-do-attitude.

Discovery is all about play-based experiences for learning about our world – constructing and creating meaning, tinkering with problems and keeping our curiosity alive.

At Abbotsleigh, our aim is to develop such a culture where there is real joy in learning. Whether our students are designing and creating a bee friendly garden, creating 3D representations of animals brought to life with BBC microbits or participating in an interschool drone challenge, our purpose is to create an environment where problem solving, creativity and curiosity come to life.

Full STEAM Ahead: The Evolution of The Year 6 AbbKart Project

Kylie George, Year 6 Coordinator

What began seven years ago in 2013 as a one-lesson wonder in kit-building has evolved to the Year 6 billycart project we know and love today. When taking a closer look at how the AbbKart project has progressed over time, it comes as no surprise that these changes have coincided with the growing worldwide calls for STEAM to be at the heart of educational reform (Taylor, 2016).

Before examining how far we have come, it's important to go back to the very beginning.

In 2012, a school visit to Caulfield Grammar in Melbourne sparked an idea that eventually led to the inaugural AbbKart Derby that following year. Working in small groups, under the guidance of one of our Senior School TAS teachers, the girls used a variety of tools to construct a billycart using pre-packaged kits. One of the Science lessons in the lead up to the derby focused on the physics of a billycart and the race day was an excellent way for the girls to put these ideas into practice. The E for Engineering in STEAM had been explored and we had touched on the S for Science in one physics lesson, but was this enough?

By 2015, the need to integrate digital technologies into the AbbKart project had become apparent thereby allowing the T for Technology in STEAM to be focused on. With the support of our IT Integrators and Senior School colleagues, additional technology workshops had been included in the project. Sketch Up was a software tool that enabled the girls to digitally create a 3D model of their billycart. Coding programs such as Scratch led to the girls creating their own billycart video game. This was fun but, again, was this enough? As stated by Peter Charles Taylor, Professor of STEAM Education and Director of the Transformative Education Research Centre, 'STEM educators are being challenged to design curricula and pedagogies to develop students' disciplinary knowledge and skills, as well as their abilities as critical consumers, creative and ethically astute citizens, innovative designers, good communicators and collaborative decision-makers' (2016). It was time to set the wheels in motion!

The following year saw a significant shift in the way we purposefully programmed the AbbKart project to enable a full STEAM ahead approach. The first change was a simple one, yet essential in ensuring the girls' learning was authentic and significant. This iteration saw the girls being given a design brief – their task – to create a prototype of the optimum billycart that centred around the theme of 'speed'. The actual billycarts being raced on derby day were fun to dismantle and reassemble, but designing a prototype of the optimum speed machine was where the rich learning would take place. As with any design task, they needed to be aware of their users and constraints such as timing, resources, function and form.

Collaborating in small groups, their decisions needed to be recorded using a Process Log that documented their thinking. But in an already packed curriculum, where did we find the time to make this happen?

One of the most important changes was integrating the AbbKart project into our Science and Mathematics programs – in other words, the S and M in STEAM. In collaboration with our Science specialist teacher, the girls spent an entire term on the Engineering Design Process testing, designing and prototyping an original yet functional billycart. The girls spent one Mathematics lesson a week sketching thumbnail versions, varying perspectives and detailed orthographic drawings that accurately represented the prototype design.

The A for Art in STEAM was another aspect of the reinvigorated AbbKart project that has enabled the girls to be creative and critical thinkers. One requirement of the design brief was for each group to create a team name, logo and colours. In collaboration with our Senior School TAS team, and as part of our Senior School Orientation program, the girls used the TAS facilities to screenprint their logos onto team flags that were waved on derby day. The girls also used the laser cutter to create number plates which were affixed to the back of their billycarts to make them identifiable. On Derby Day, each group displayed an A4 board to accompany their prototype that encapsulated the learning process they had embarked on in creating their prototype.

An unexpected advantage of the most recent iteration of the AbbKart project has been for the girls to experience a community of learners. Not only do the girls collaborate with one another, but they also have the opportunity to work side by side with many members of the school and wider community. To spark their initial thinking, external providers run an introductory incursion about billycarts. National Roads and Motorists' Association (NRMA) scrutineers are invited to assess the safety standards of each billycart. The girls have worked with their classroom teachers, specialist teachers, IT integrators, maintenance team and Senior School teachers in accessing the expertise of everyone involved. On Derby Day, the entire school community, including parents, are invited to share in this celebration of learning. It truly does take a village to raise a child – and build a billycart!

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Abbotsleigh Robotics Team: Engineering, Mathematics, Inspiration, Science (ARTEMIS)

Susan Filan, Head of Environmental Education and Science teacher and
Erin Filan, Robotics mentor

The Abbotsleigh robotics team embodies its mission statement in its name, as well as referencing a strong woman from mythology. Strong role models and exciting challenges are encouraging students to embrace the opportunities for problem-based learning through robotics.

ARTEMIS started in 2015 with Middle School students competing in the RoboCup Dance FIRST™ LEGO™ League (FLL) competitions. Older students competed in the Duel Down Under, a FIRST™ Robotics Competition (FRC) off season event. Their first FRC robot, Hugbot, had a standard drive base and a superstructure made of scrap wood from the TAS labs. From these humble beginnings, the program has grown and encouraged many girls to consider tertiary study in engineering and/or computer science. The 2019 robot, Callisto, is a far more sophisticated machine designed using CAD and multiple prototypes, featuring a camera for a robot-eye view and pneumatics allowing it to climb a step.

Students and mentors worked tirelessly in 2015 to gain a 2016 rookie grant from the Argosy Foundation and sponsorship from both Ford and Sell & Parker Metal Recycling during the first year. With a larger crew of mentors and a lot of hard work, ARTEMIS won the prestigious Rookie All Star Award in 2016 and attended the FRC World Championships in St Louis, USA. At this competition, students met teams from around the world, learnt more about robotics and discovered the many career directions that can spring from robotics experience.

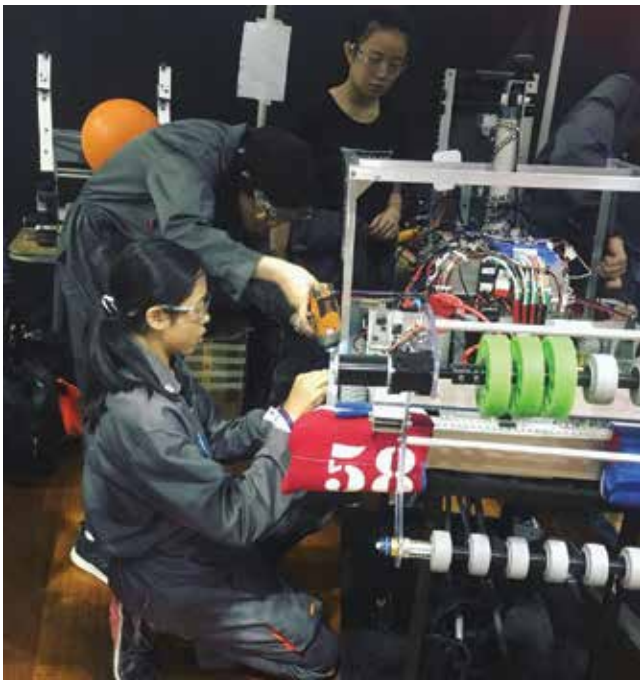
FIRST™ is more than just a technical competition. FLL students must research a real world problem each year and propose an innovative solution, in addition to programming a robot to play a challenging game. FRC students participate in community service to encourage others to engage in STEAM.

Abbotsleigh students and mentors have served hundreds of volunteer hours at robotics events. In 2018 and 2019 ARTEMIS partnered with CanTeen and the Starlight Foundation to bring robotic fun to more than 170 hospitalised children and teens.

Over the weekend of the 15-17 March 2019, Abbotsleigh girls and their robotics mentors volunteered and competed in two international robotics competitions at Olympic Park. These were the culmination of six intense weeks of brainstorming, prototyping, CAD, wiring, making parts, testing and coding. The 2019 game is called Destination: Deep Space and is presented in collaboration with the Boeing company. The students who had designed and built Callisto spent three days playing three-on-three robot matches; driving, repairing and often breaking the robot during the 2.5 minute matches. They finished the tournament ranked 23rd out of more than 60 teams and sadly did not make it to the next level of competition. However, the girls were still winners because they learned about strategising, data collection and communicating with teams from other countries. They helped fix the robots of others, implemented safe work procedures, presented their ideas to the heads of companies and so much more.

Students involved in robotics show gains in conflict resolution, communication, time management and problem solving. They are more than twice as likely to take tertiary courses in engineering. All these impacts are amplified for women, with FIRST™ students showing dramatically increased understanding of STEAM compared to control groups. We have seen these impacts at Abbotsleigh, with 100% of ARTEMIS alumni going into tertiary education and 60% studying in STEAM fields.

The robotics program is unique in that it allows students to engage with STEAM in a variety of ways, from video making to essay writing to computer modelling. Students focus on collaboration and group work, crucial skills for the modern workforce. Everyone contributes ideas during brainstorming processes and then, as a team, select designs to prototype. The skills learned in robotics can be applied across the curriculum and in daily life as students learn the value of risk-taking and perseverance, explore problem solving processes and experience the deep satisfaction of providing service to others.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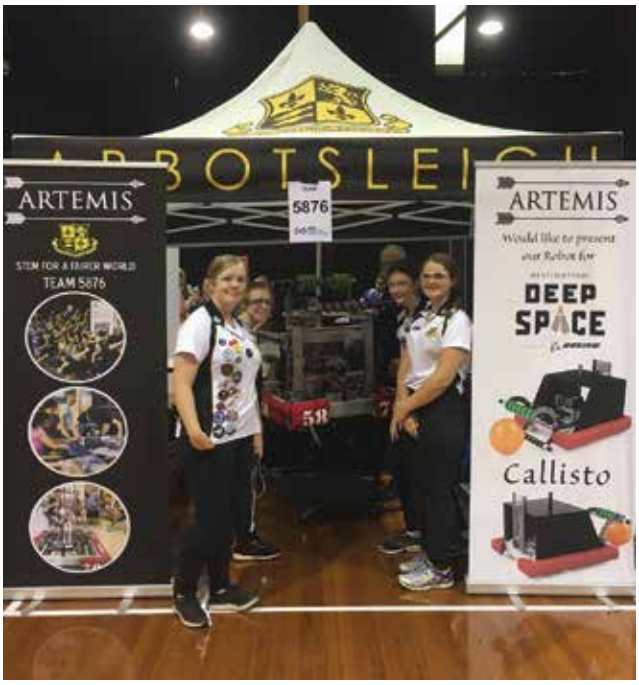
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STEM FOR A BRIGHTER WORLD
TEAM 5876
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ARTEMIS
Would like to present
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DEEP
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Bridge Building Challenge

Kim Allan, Mathematics teacher

Service and reaching out to the community were key drivers of this bridge-building initiative. This came from a desire for students to be more outward focused, to have a greater awareness of needs in the wider community and consider how they could play a part in meeting some of these needs.

Natural disasters and the need for humanitarian aid were looming large in the world and so it was decided this could be a good way of integrating Mathematics and Science with service.

The Challenge

The challenge was in four parts.

1. Build the strongest, cheapest bridge across a river to provide supplies to a small village cut off due to flooding which had destroyed their bridge, the only means of reaching the outside world.
2. Take supplies in a 'pod' which was a Sphero. Program the Sphero to get across the bridge and land at the village without falling off the bridge or over-shooting the village.
3. Decide what supplies would be taken to the village, given a set budget and a list of supplies with the cost of each item.
4. Create a pitch to 'sell' their bridge to a UN representative.

Developing the unit of work

Staff were initially given two days to collaborate and develop the basis for a STEAM project for Year 7 Mathematics and Science students. Specialists attended the meetings to assist in the initial stages and the development of a 'hook' to gain student interest in the project. The teachers then worked on these initial ideas in their own time to develop a full unit of work.

Two teachers, one Mathematics and one Science, worked on the bridge building aspect, trialling various methods using spaghetti. They filmed their efforts and fine-tuned materials and examined various challenges which may be faced by students when completing the engineering aspects of the unit of work.

Two additional teachers, one Mathematics and one Science, worked on a student handbook to guide them through the project.

Scaffolding

A student workbook was compiled to guide students in their preliminary investigations, design and final bridge construction, calculation of costs and decision making to determine which supplies would be provided for the village in need.

The handbook included details of the costing of building materials and relief supplies to be used in the final calculation of the budget.

Format of the day

The day was divided into four 80-minute periods.

Students worked in groups of three or four to complete the project. The first time the project was undertaken, students were given time during Mathematics and Science lessons. After the first year, it was decided that this was rather disjointed, and a full day was given to the task.

Students worked in the Science laboratories, assisted by Mathematics and Science Teachers during their timetabled Mathematics and Science lessons and supervised by other teachers who would normally have taught them. Each lesson was 80 minutes in length.

In the first year, students were given a large amount of sticky tape and it was decided to reduce the amount for future years. This was because students used large amounts of tape and laminated the bridge. It was decided that students should be encouraged to use more creative methods for solving the problem. To provide further challenge, the distance across the river to be spanned was also increased so that students had to use more than one length of spaghetti to cross the river, increasing the level of challenge.

Each group was provided the following basic materials.

- One 500 g packet of spaghetti
- One roll of tape
- Four elastic bands
- A Sphero
- A box to simulate the cliff and village
- Paper to represent the river to be crossed

Period 1

The day began with students competing in groups to build the highest, most stable tower using spaghetti and marshmallows. This led to a discussion of stable structures and a follow-up activity testing the strengths of various shapes using scientific and mathematical principles.

Ramps were used to determine the optimum angle for the Sphero to aid students in the design of their bridges.

Videos of bridges under extreme environmental conditions were shown to students to give them a greater understanding of the forces at play and to promote deeper engagement with the project. There were examples of good and bad bridge designs followed by a discussion of the various elements needed to construct a stable bridge.

This was followed by time for students to plan and design their bridge. Students were also required to code a Sphero to traverse the bridge and stop at the village. This was to simulate a transportation vehicle taking supplies to the village.

Period 2

Students worked in groups to build their bridges. Each group was provided with a large box; the side of the box was the cliff where the bridge had been washed away and the top of the box was the location of the village.

Taping the bridge to the cliff or any 'land' was not permitted; students had to devise methods of securing the bridge to the cliff.

Period 3

During this time, students fine-tuned their bridges. In addition, they completed their budget and worked on their Sphero program and presentation.

Tutor time

Thirty minutes was allocated to a gallery walk. Students visited assigned classes and used post-it notes to make suggestions for other students, such as: I liked... Have you considered... Something interesting about your design is... You could make your design more efficient by...

Students also used this time to finish their budget, presentation and bridges if they needed extra time, or make modifications on suggestions made during the gallery walk.

Extension activities included:

- Researching ethical issues related to aid provision in natural disaster areas.
- Debating a topic related to disaster relief, international aid and refugees.
- Designing a bridge using materials that may be found at the site of a disaster.
- Designing and building a model of a new, creative bridge to go across the Pacific Highway from the School using recycled and sustainable materials.

Period 4

Students voted on one bridge from each class to go into the final competition and crush tested the bridges that were not selected. Individual teams demonstrated their Sphero in action.

All teams entering the final did a crush test in unison – each team adding the same weight to their bridge, at the same time, to find the strongest bridge. Prizes were awarded for strongest bridge and most economical bridge.

Assessment

Peer reviews were an important aspect of the assessment process. Feedback was given by students when they went on the gallery walk. Students also included reflections in their presentations to their class and the whole year group. These reflections included what they had learnt from the experience and how they would improve their designs if they were to do it again.

Student Feedback

Student feedback was positive and enthusiastic. Students enjoyed the time to experiment, work together in groups and consider how to apply their learning in Mathematics and Science to a real-world situation.

A Fuller Engagement

Pat Griffiths, AbbSchool Manager

Gender differences in educational and vocational choices for STEAM subjects have attracted a wide range of studies and theories. Among these, Eccles proposed that "educational, vocational, and avocational choices would be most directly related to individuals' expectations for success and the importance or value they attach to the options they see as available." Her research found that self- and task-related beliefs are shaped over time by experiences with the related school subjects and activities, and a student's subjective interpretation of these experiences.

Abbotsleigh understands the value of these experiences and offers an extensive extra-curricular program which includes many STEAM related activities, allowing students of all ages to learn, discover, socialise and above all enjoy the STEAM learning experience. These popular activities play an integral role in encouraging and shaping ongoing interest, providing girls with experiential learning opportunities that incorporate investigative, problem-solving challenges and creativity and design skills in a stimulating environment which is a complementary alternative to the classroom.

FIRST Robotics, with their wonderful values-based ethos, is one such program offered by Abbotsleigh. In a FIRST longitudinal study, participants showed an impressive increase in interest and involvement in STEM- related activities and careers, STEM identity and STEM knowledge/understanding.

Between 94-98% showed greater awareness of STEM, increased confidence, increased interest and increased persistence in STEM. In the area of 21st century work-life skills gained by FIRST participants, 98% showed improved problem-solving skills, 95% increased time-management skills, 93% increased conflict resolution skills and over 76% displayed strengthened communication skills. And over 75% of alumni are in a STEM field as a student or professional.

These results indicate statistically significant positive impacts in life skills, career interest and educational choices for young students.

One reason extra-curricular activities produce such positive outcomes is that they are self-selected and based on the intrinsic interest of a student. Voluntary participation in discretionary activities fosters self-assessment and clarification of one's talents, values and motivations. To choose what, when, how and with whom creates an inherent sense of empowerment and allows students to develop their interests, talents and skills independent of curriculum courses. One of our junior students said she loves Code Camp because "We learn different things to what we learn at school", and another said, "I love problem solving and it's really interesting how codes can make a really cool game".

It is not just that extra-curricular STEAM activities are complementary to curriculum courses, they are popular and sustained by the students themselves. They are interesting, instructive, stimulating and fun. And more than this, they facilitate a fuller engagement with STEAM learning.

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Eccles, J. (2007) Where Are All the Women? Gender Differences in Participation in Physical Science and Engineering, New Directions for Child and Adolescent Development, No. 110, Winter 2005.

It's All Right to Make Mistakes in Mathematics

Betina Wrightson, Head of Mathematics/Head of Gifted and Talented

One of the myths of Mathematics is that a correct solution can only be found once a process or rule is followed. At Abbotsleigh, the Year 7 students have used the research of Jo Boaler, a Professor of Mathematics Education at Stanford, to discover that it is all right to explore and play with mathematical concepts and problems. The lessons have been developed so that the students can discover that there isn't just one way of coming up with an answer, that maybe there might be more than one solution and that mistakes along the way are good, since in making mistakes, you learn so much more.

The students have been given opportunities to explore and make mistakes using the many examples developed by Jo Boaler and her team at YouCubed. The problems are designed to enable them to focus on their logical reasoning, strategic thinking and deductive reasoning skills, all of which are important "21st century skills".

Working in groups of two or four, the students are given problems that enable them to think differently and normalise the idea that mistakes are okay, especially when they are exploring something new. The students have also been encouraged to explore that there might be more than one answer and to entertain the possibility that they might be able to create a generalised expression and find myriad solutions.

The problems that the students encounter in this course are designed to be more open ended and discussion is a regular part of the learning process. The encouragement of students to think more deeply about their answers and to make connections and reason/justify their responses rather than getting the correct answer quickly, has been one of the successful outcomes of this approach.

As Eddie Woo a passionate Mathematics teacher and Australian Local Hero of the Year said in part of his 2018 address, "Mathematics is less about finding answers fast and more about slowing down to ask the right questions. I learned that Mathematics is not about mindlessly stepping through algorithms, but rather about imagining new ways to see problems so they can be solved with creative and unexpected techniques."

It is hoped that with this new initiative in Year 7 Mathematics we are encouraging our students to see the beauty and joy in mathematical pursuits rather than just a set of meaningless rules to be memorised.


Beginning
Developing
Expanding
Open Tasks
Tasks are relatively closed, emphasizing procedures with little reasoning
Rich tasks are occasionally used
Tasks are mathematically rich in reasoning opportunities, allowing for different approaches and visuals
Reasoning and Multiple Perspectives
Maths work does not include reasoning, visuals, or multiple perspectives
Occasionally multiple methods and visuals are elicited and explored
Students use and share different ideas, visuals, and methods & use ownership words - e.g. "my method"
Depth Over Speed
Strong emphasis on speed, memorization, and correct answers
Occasional emphasis on speed, memorization, and correct answers
Emphasis is on depth, creativity, visuals, and mathematical beauty

Look Up, Reach Out: Connecting the Abbotsleigh Community

Joel Ford, Teacher Librarian

"Here I am, please tell me your story; here is my story, please listen." (Orlean, 2018, p. 310)

In 2005, I spent some time volunteering in India and I was very fortunate to meet an amazing Tibetan couple, who taught me a great deal about the power of the human spirit. They were forced to flee their homeland and when I met them, they were living as refugees in the north of India, stateless and facing an uncertain future. Our conversational English classes soon evolved into a discovery of their incredible personal stories and it was they who quickly became my teachers. When I left India a few weeks later, I presented them with a journal, where I retold as accurately as I could what they had shared with me. I felt honored to be entrusted with their stories and at the same time, I knew that these stories needed to be told. I wrote my email address in the journal, but as happens over time, we lost contact and moved on with our lives.

Then in September 2017, I received an email:

"Dear my English Teacher Joel, how are you these days? Do you remember me? I am Ngawang Jampa and I am in Dee Why NSW with my wife Ghang Lhamo."

Amazingly, fate brought them to a new life in Sydney and I was able to meet my friends again, and when we reunited, they brought with them the journal I had presented 12 years earlier, along with new stories to be told.

Life experience confirms for us that regardless of our backgrounds or our differences, we all have stories to tell and *"all these stories matter, and so does every effort to create something that connects us to one another, to our past and to what is still to come."* (Orlean, p. 309)

As a Teacher Librarian, my role involves enabling students and staff to connect with information and resources to help them learn but, I've realised over time, that we often neglect the best sources of information available to us... the people in our school communities.

Inspired by initiatives and opportunities such as TED, Humans of New York, and the Human Library (see suggested links/reading), I sought to find an opportunity to develop a project that would connect our school community through our stories, skills and passions. The ideal opportunity arose towards the end of 2018 when the new Abbotsleigh Prefects announced their theme for the following year: 'Look up, Reach Out'. Combined with the students' Service Project theme, 'Connect our Community', this gave me the inspiration to apply for a research grant through the Abbotsleigh Foundation, with the aim of creating a 'Living Library' that connects and builds relationships between all members of our school community... past and present students, staff, parents and friends.

The ultimate aim is to establish a permanent online resource, which for want of a better phrase, acts as a human database, which collects and catalogues our stories, skills and passions, so that we can connect with and learn from each other, just as we learn from any other invaluable resource.

The ideals of the Abbotsleigh Strategic Plan emphasise Individual Empowerment, Educational Innovation and Organisational Strengths, all characteristics of a community that shares its knowledge and values the experiences of its members.

According to social researcher Hugh Mackay (2018), all humans want to be respected, acknowledged and appreciated and in turn, we are grateful and empowered when given the opportunity to tell our stories and contribute to the learning and growth of those around us. As humans we should actively seek opportunities to listen to each other and build empathy and while this means we need to be open and at times, vulnerable, the rewards are almost guaranteed. By starting these projects in our school communities, we can break down barriers and our students can lead the conversations so that ultimately, we create more open and accepting local and global communities in the future.

Currently, our Abbotsleigh 'Living Library' project is still in the planning and development stage as we work with the community to find the best ways to connect. Our first ever TEDxYouth@Abbotsleigh in 2018 was one such initiative and we are currently planning for our next TEDxYouth in 2020. By the time this article is published, through the leadership of Pre K-12 ICT Integrator, Jeanine Kobylinski, we should also have progressed on the development of our online 'Living Library' space. Plans are underway for a Humans of Abbotsleigh style feature, along with other storytelling initiatives (podcasts and interviews), which will hopefully lead to Abbotsleigh's 2019 theme of 'Look Up, Reach Out' becoming a lasting legacy for our school community. Because connections are ultimately about

conversations, a scene from A Star is Born (2018) sums up the project perfectly.

Jack: *Look, talent comes everywhere... but having something to say and a way to say it so that people listen to it, that's a whole other bag. And unless you try to get out and you try to do it, you'll never know... and there's one reason we're supposed to be here is to say something so people want to hear. Don't you understand what I'm trying to tell you?*

Ally: *Yeah, I do. I don't like it, but I understand it.*

Jack: Oh, I think you like it a little bit.

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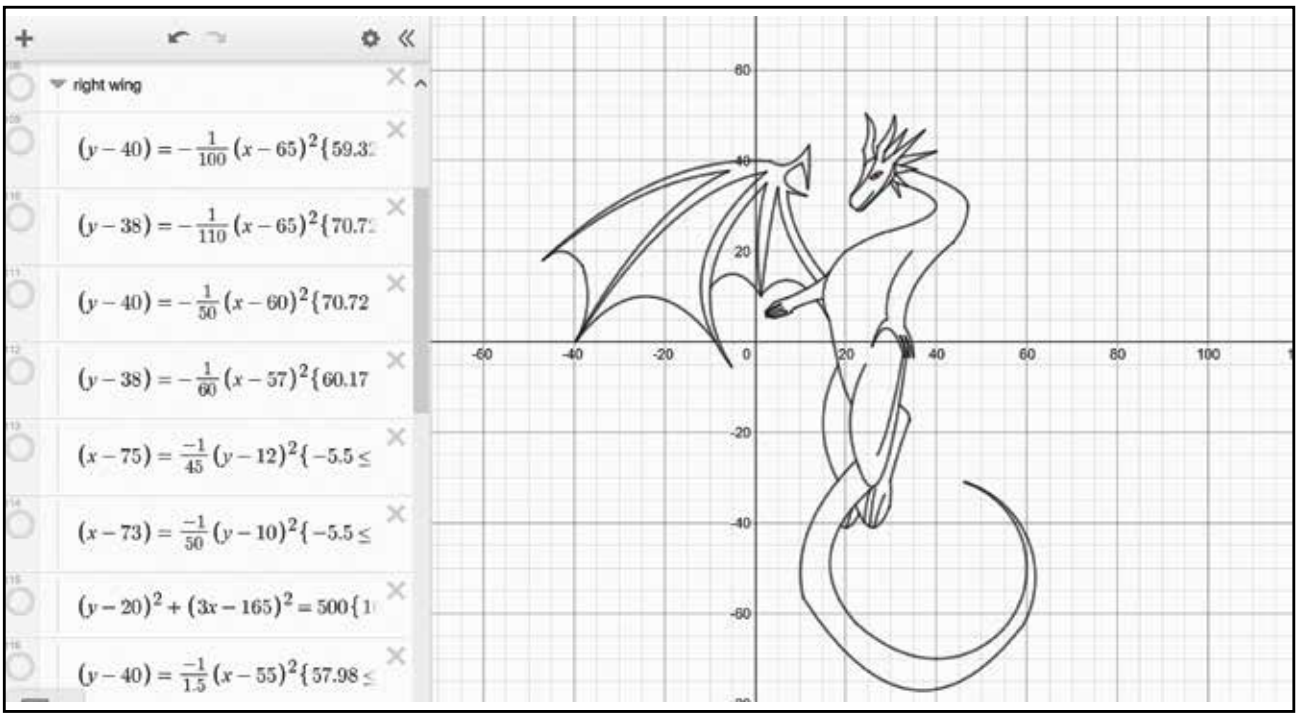
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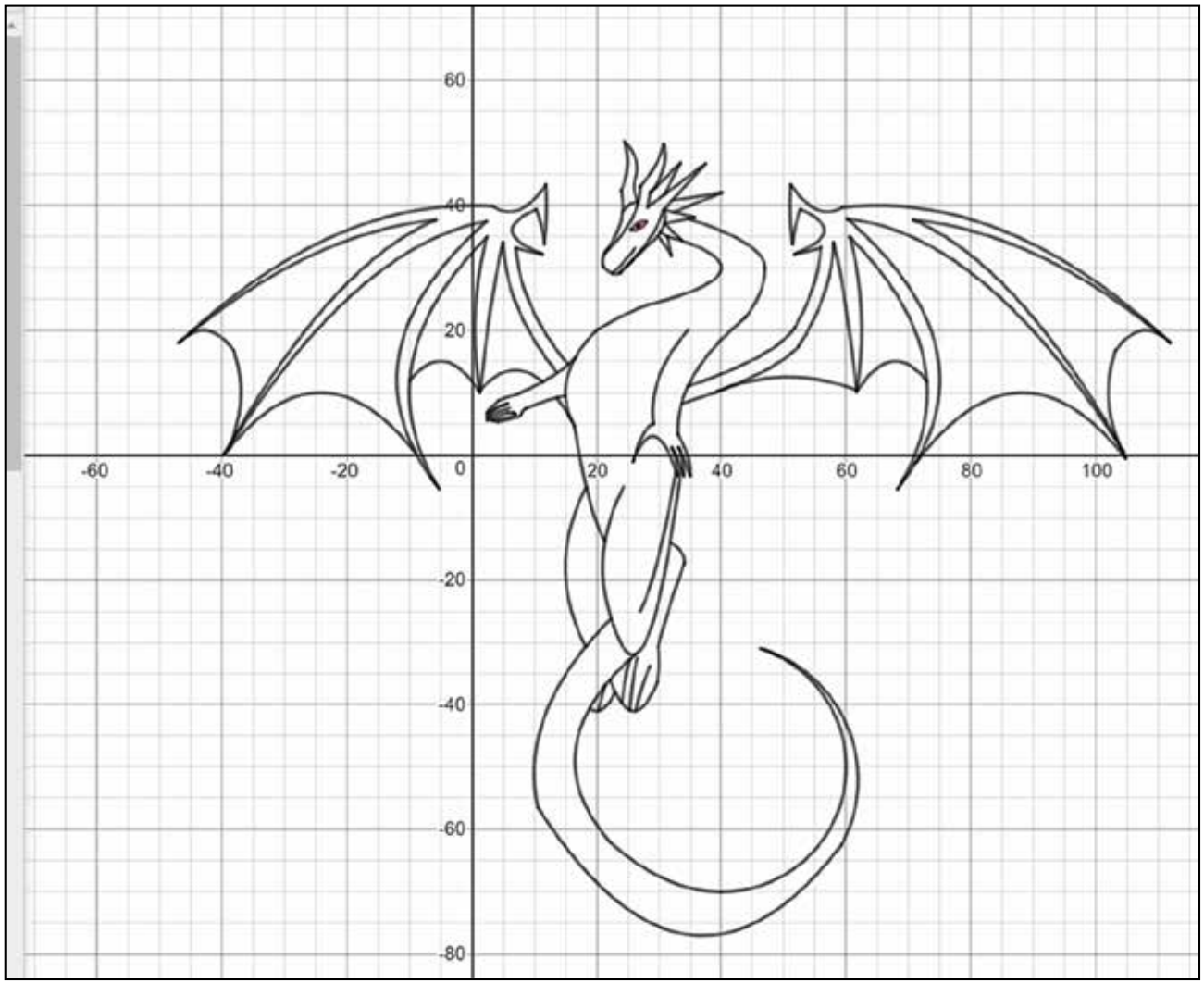
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Dragon

Carmel Burke, Mathematics teacher

Occasionally we are fortunate enough to have a student totally immerse herself in an activity; to run with a simple idea, a simple task and create something amazing.

At the end of Term 4, a Year 10 Mathematics class was consolidating the concept of linear function and, in particular, the algebraic relationship between two variables and the graphical interpretation of the same relationship. This is akin to the 'book' version of the story compared to the 'movie' version of the story. Both versions have their advantages, and both versions tell the same story.

The brief was simple: create a five-pointed star by using a series of algebraic linear functions in the web-based graphical software application, Desmos (www.desmos.com). Students used iterations of linear functions, adjusting the gradients and intercepts of their lines. They determined the need to limit functions between certain x or y values. The necessity for restricted domains (x values) or ranges (y values) was born. There were some students who felt more comfortable using precise values and decided that past knowledge of graphical simultaneous equations was the perfect solution. While other students came about this process from a more experimental approach.

From this simple exercise, students went on to create images of Christmas scenes and finally replicated a cartoon character. When particular curves were required, students researched other images on the Desmos site and identified the functions that had been used. They created semi-circles, parabolas and hyperbolas by manipulating constants in the algebraic formulas to change the curves.

Students developed a deep understanding of functions through the design of a piece of art. Playing with the concept of 'what if', manipulating and tweaking algebra, provided a safe environment to FAIL (First Attempt In Learning). With constant iterations and adaptations, students established a sense of mastery of these abstract concepts.

This confidence became evident when they completed core function topics the following year in the Stage 6 Advanced Mathematics course. The opportunity to explore and consolidate graphical and algebraic relationships in a creative environment enabled the students to transfer and apply skills and knowledge to a formal learning setting. Students were confident with their understanding and able to apply their knowledge to more complex functions.

GLOW

Donna Moffatt, Director of Learning Innovation
and Terri Moore, Head of Curriculum, Innovation and Design

For the past four years, Abbotsleigh has held an annual festival of light – GLOW. Last year, the festival was the largest it has been with a showcase of student work from all the Senior School faculties, co-curricular groups, service clubs, and every year group from the Junior School campus including the Early Learning Centre. The opening event for the 2018 GLOW exhibition was the lighting of three, 1000-foot beams of light shooting into the sky. The creation of these light beams for an Abbotsleigh Marker involved the mentorship of past parent, Professor Barry Webb AM who worked with girls from the school's stage and lighting crew on site and at industry locations.

The students created the projects displayed at GLOW as part of their work in a range of interdisciplinary STEAM and Maker Education projects. The focus of this enquiry-based approach is the development of skills such as problem solving, creativity, design thinking, and collaboration – skills which will last them a lifetime.

Microsoft Captain Marvel-themed STEM Workshop for Girls

Terri Moore, Head of Curriculum, Innovation and Design

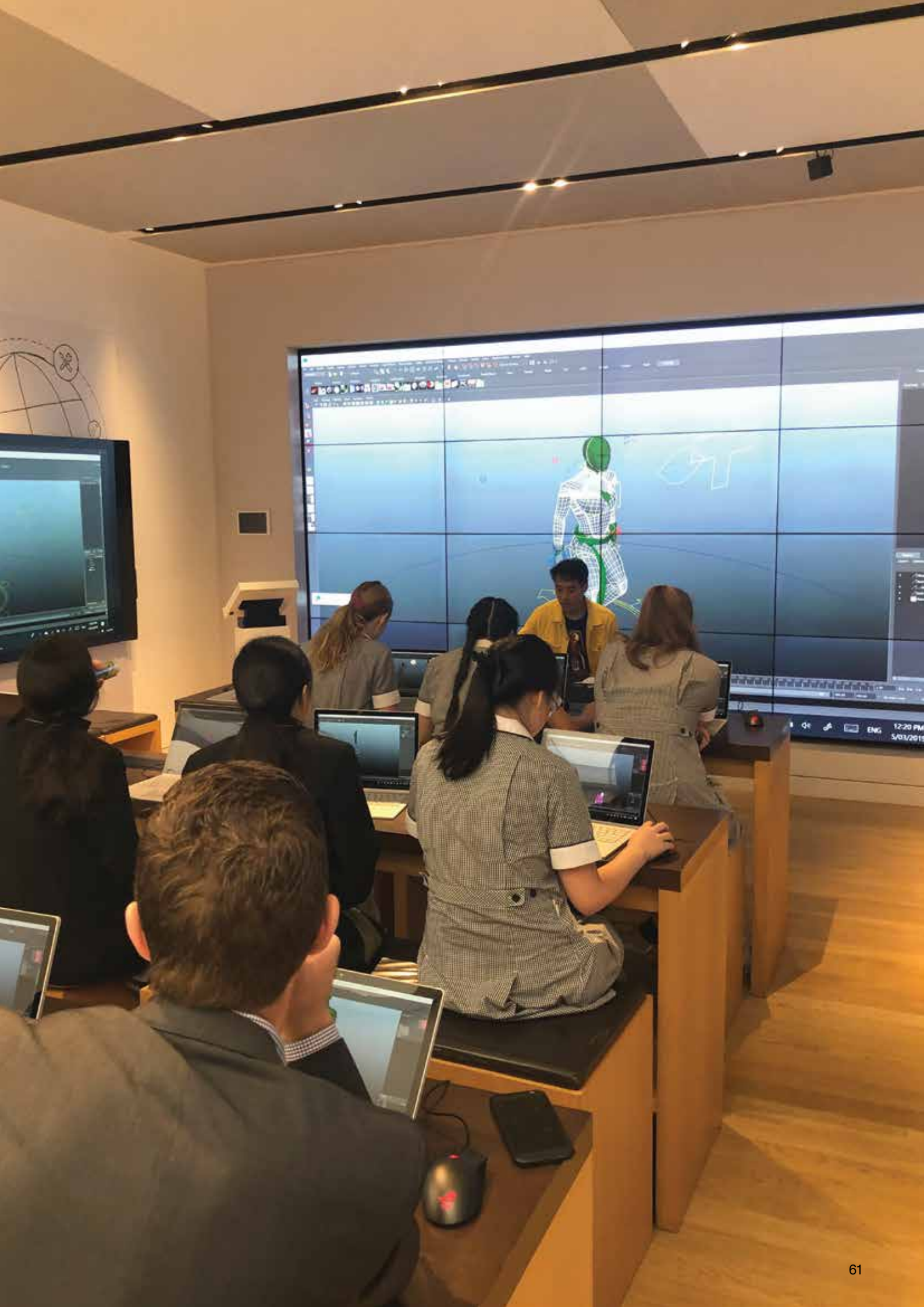
'Higher, further, faster, baby.' Carol Danvers

Captain Marvel, the first female superhero movie from the Marvel universe, launched on International Women's Day, 8 March 2019. In collaboration with Tap Tap Comics, Microsoft invited Abbotsleigh to participate in the international launch of the Microsoft Captain Marvel-themed STEM workshops for girls at the Microsoft Sydney Flagship Store. The purpose of the campaign is to empower young women in technology through animation and coding workshops.

Our Year 10 Information and Software Technology students and Year 11 Software Design and Technology students engaged with a panel discussion from inspirational women who are pioneers in their area of STEM including coding, animation, technology and physics education. The panel discussed the responsibility of women as role models for girls interested in STEM, highlighting how women within industry play a huge role in attracting young girls into STEM careers and inspire them to take risks and to reach further into the unknown. Through their questions, our girls demonstrated deep thinking about issues associated with gender equity, access to technology and expectations of women.

The girls then engaged with two widely used industry software applications, Unity and Maya, to code simple animations and create Captain Marvel inspired characters and storyboards. Unity is a game development platform used to build high quality 3D and 2D games. Maya is a 3D animation, modelling, simulation and rendering software that is used for animation, motion graphics, virtual reality and character creation. Our girls applied skills in computational thinking to reach higher and meet the challenge of designing to an industry standard. Much fun was had in the designing process, experimenting with character movement and discovering the need for accuracy in their coding to create the prefect body motion in their character.

Reflecting on the day there was excitement in leaving with a wider view of the application of STEM subjects in technology careers. It was an honour to be invited to be the first school to launch the Microsoft Captain Marvel-themed STEM Workshop for girls.



Agriculture: The Original STEAM Subject

Susan Filan, Head of Environmental Education and Science teacher

The Abbotsleigh Agriculture Club has embraced learning opportunities through competitions at the Sydney Royal Easter Show. School competitions involve both a learning project and the practical experience of growing animals or plants.

The Steggles Meat Pairs Competition is a real eye-opener for students as cute little chicks turn into hefty 3.5 kg broiler chickens in six to seven weeks. After raising prize-winning birds on turkey starter feed in Term 1 2018, the girls decided to run a feed trial comparing turkey starter to meat bird feed in Term 2. The two feeds have different amounts of protein and the graph shows the effect on growth from chicks hatched in the same batch. This experiment provided them with evidence of the effectiveness of high protein turkey starter in order to raise top quality meat chickens.

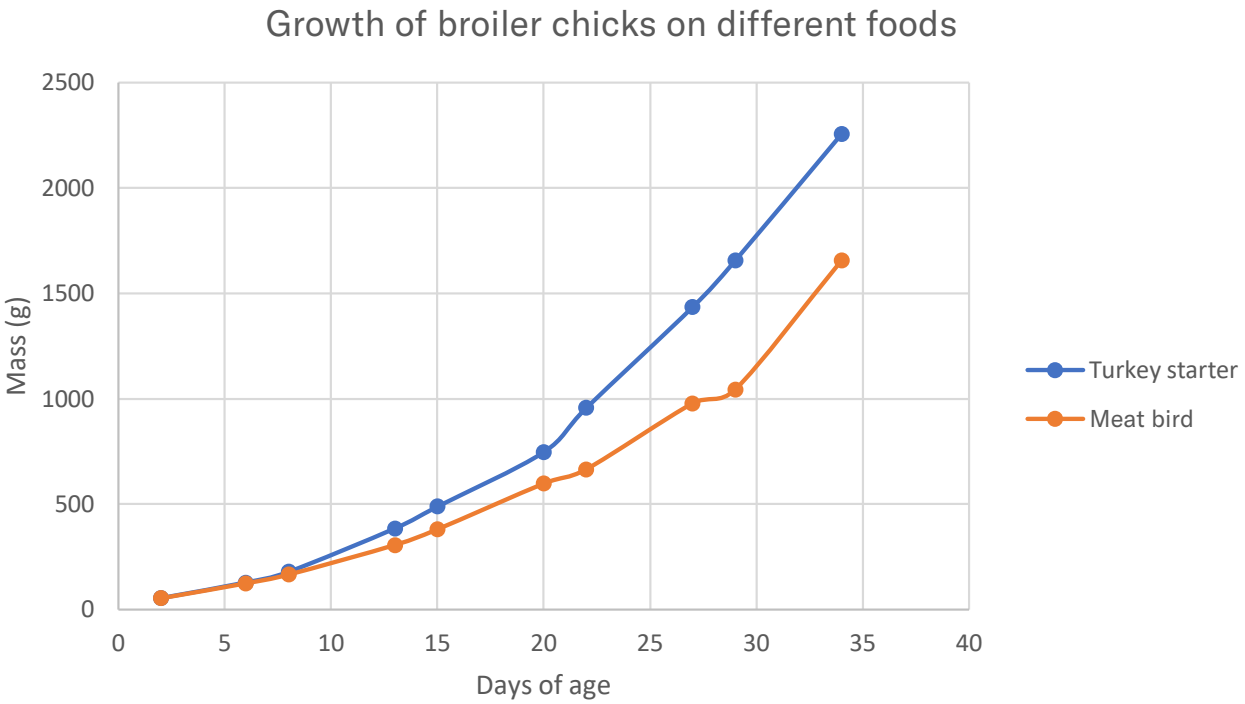
Raising competition birds involves careful measurement of both the growing birds and their food supply. Students must calculate the feed conversion efficiency of their flock. This is a measurement of how many kilograms of food go into each kilogram of live bird. The 2018 competition birds had a feed efficiency of 1.4. This is an amazingly low number compared to approximately 6 for feedlot cattle. This efficiency makes barn-raised poultry the most environmentally friendly land-based meat.

Students prepare a project that reports on the growth and husbandry of their birds, as well as the poultry industry in Australia. The project component helps students gain a better understanding of primary production and the importance of Australian agriculture. Despite the Australia Day advertising campaigns, the average person consumes 49kg of chicken meat and only 8.2kg of lamb each year. Chicken has been our most popular meat since 2009 and continues to increase in popularity.

In addition to the meat bird competition, girls learn about egg production in the Purebred Layers competition. They also prepare a project about their care of the birds and the egg industry in Australia. The 2019 flock is composed of friendly Australorp hens that were sourced from the Central Coast Poultry Club. Girls demonstrate their bird handling skills and breed knowledge during the School Showmanship competition.

The club has branched out into produce for 2019, entering both the vertical garden and normal garden competitions. As for all school competitions, there is a project component in which students must learn about fruit and vegetable production and consumption in Australia. Creativity comes to the fore as the girls must present at least five different types of produce in a themed basket.

Agriculture offers many opportunities to enjoy time with animals and plants, learn about primary production and get creative in preparing exhibits for the Sydney Royal Easter Show.


Growth of broiler chicks on different foods
Mass (g)
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500
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0
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10
15
20
25
30
35
40
Days of age
Turkey starter
Meat bird

The World In Miniature

Tom Cameron, Head of Science

When you look around you, what do you see?

The world is filled with all sorts of things to look at. Trees, birds, people, cars, architecture... the list goes on.

If you look up at the night sky, you may see the moon, stars and even distant planets. Some of these objects may be millions of miles away. Isn't it amazing what you can see with your eyes.

Would you believe, though, that there are myriad things close by that we can't see? Things like germs, bacteria... even dust mites... are all around us and invisible to the naked eye.

Each year as a part of the Year 8 STEAM program students take part in the MyNute program. Throughout the program, the girls are engaged in the full range of STEAM disciplines: Science, Technology, Engineering, the Arts and Mathematics. Much work is undertaken in the weeks leading up to a full day of workshopping, including studies of rates and ratios in Mathematics, digital photography and surrealism in Visual Arts and single lens microscopes in Science.

MyNute teaches the girls about the microscopic world and how it can be investigated. Embedded in the program is the concept of magnification and how through the use of lenses we can bend light at an angle to increase the size of the image that is sent to your eye.

As the image sent to your eye increases in size, you can see an object more easily, even though its physical size has not changed.

Experts believe that the naked eye can see objects as small as about 0.1mm – that is about the width of a single human hair. Today with the help of powerful microscopes we can see things that are around 0.001 mm in size.

During the MyNute program our students take the lens from a recycled disposable camera and fit this to their own mobile phones to create their own 'microviewer'. Students are then sent out to investigate the microscopic aspects of the world they 'see' every day and to take photos using their new microviewer.

Having selected their favourite photos, students then put their photoshop skills to use and place a 'normal' sized object, such as a person, into their microscopic world. The result is some very creative images.

Almost to the Moon and Back

Elizabeth Russell, Assistant Head of Department, Science

Why would 30 girls in Years 7 and 8 elect to engage in a rigorous program of STEAM study in the first two weeks of their summer holidays in December 2018? Perhaps there was something in the destinations of Kennedy Space Centre in Florida and a visit to the Smithsonian Museum in Washington DC that piqued their interest and passion. Certainly, the teachers' intent was to immerse the girls into STEAM based learning that would provoke curiosity, wonder and excitement by engaging them in experiences unattainable here in Australia.

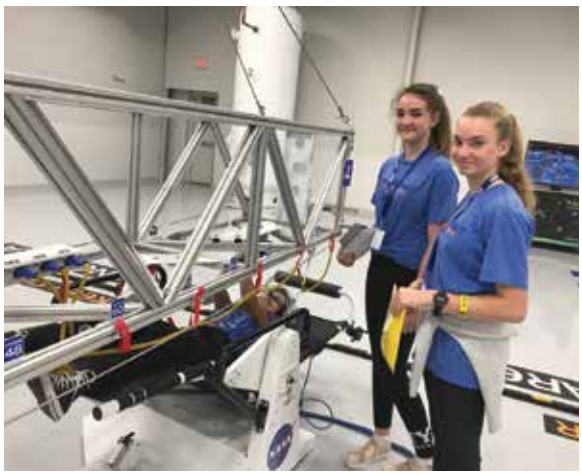
The Kennedy Space Camp gave first-hand experience of the challenges and complexity of space travel. Despite tight security, access was afforded to tour launch sites for the Shuttle program and the enormous space Vehicle Assembly Building where even each US flag star measured more than two metres across. A reconstructed Apollo mission command centre and the hangar detailing the history of space flight and the moon landings, gave perspective to the long and expensive journey space travel has been. Touching a piece of moon rock, walking on the very bridge Neil Armstrong climbed as he boarded the command module and viewing the Space Shuttle Atlantis were breathtaking moments.

Undertaking the astronaut training program through a simulator experience was incredibly realistic as the girls experienced virtual reality moon walks and driving on the surface of the moon. They learnt how to use the toilet and be fastened into bed in space.

Trying to pick up a dime wearing the glove of an astronaut was a humorous lesson in the importance of intensive training in an environment where the sense of touch is absent. Eating in space took on a different meaning when the girls discovered the cost of simple everyday items suitable for space travel and the lengths undertaken to provide an individualised, nutritious menu for each astronaut, including treats.

The Mars expedition day moved from replicating past experiences to sharing current research as scientists seek to find ways of supporting life on this planet. This included growing crops in greenhouses suitable for Mars and using robots to clean off solar panels. The girls were faced with the dilemma of deciding whether to heat water for a shower or to conserve power to enable contact with home once a week. A tough choice!

The three days at Kennedy exceeded all expectations. We were then off to Universal Studios in Orlando. After a day of being a tourist, the girls returned to investigate the science, engineering and physics behind the ride's construction. Popular vote identified the Rip Ride Rockit as the one to be analysed behind the scenes. The finale, of taking the ride without queuing, certainly made evident the joy that is had when STEAM disciplines combine. This city had one more surprise as the girls experienced the iFly. This was an interactive presentation on the aerodynamics of flight followed by a demonstration in a wind tunnel that saw each girl 'fly'.



After exploring motion in space and air, a very different experience awaited at Crystal River in Florida where a water wonderland is found. What a privilege it was for the girls to not only hear of the habitat, adaptations and migratory behaviours of the endangered manatees, but to also swim with them! Each donned wetsuit, snorkel and mask before slipping into the spring-warmed waters that attract the manatees during the cooler months. The size, fluid motion and gentle nature of these huge creatures were breathtaking.

For the final night in Florida the fun and entertainment value of STEAM based activities was made real to the girls with an after dinner show at Wonderworks – the Questacon of the USA. Additionally, they interacted with more than 100 hands-on exhibits showcasing innumerable scientific facts and principles. This experience contrasted well with visits to the Smithsonian Natural History Museum and National Air and Space Museum in Washington DC. From the Hope Diamond and the exhibit on Epidemics in a Connected World to the Ocean Hall and the history of flight, there was far too much to see in a day's exploration. Of course, a trip to the capital of the United States is not complete without a walk along Constitution Avenue for a tour of the historic Capitol Building. The trip concluded with a night tour of the main sights including, the Christmas tree at the White House and being moved by the site of the Lincoln Memorial.

Girls can't be what they can't see. This action-packed and intensive 12-day trip to the US gave the girls the insight and hands on experience into domains and careers in STEAM never previously experienced or understood. Thanks to the wonderful planning, pastoral support and provocation of our teachers, every girl came home with lessons and memories to last a lifetime.

STEAM

Advancing innovation in Science, Technology, Engineering, Arts and Mathematics education

"Learning is not only the development of the fundamental competencies (skills and knowledge) necessary for the successful negotiation of an uncertain world. It is also about developing the personal, interpersonal and cognitive capabilities that allow one to diagnose what is going on in the complex, constantly shifting human and technical context of real world practice and then match an appropriate response."

New Pedagogies for Deep Learning Whitepaper: Education PLUS. Michael Fullan and Geoff Scott, July 2014

Why engage in STEAM?

"Students in STEM programs may have more experiential learning opportunities, but they are limited to only science, technology, engineering and math... STEAM is a way to take the benefits of STEM and complete the package by integrating these principles in and through the arts. STEAM takes STEM to the next level: it allows students to connect their learning in these critical areas together with arts practices, elements, design principles, and standards to provide the whole pallet of learning at their disposal. STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation."

Educationcloset (2019). STEAM portal. Retrieved from https://educationcloset.com/steam/what-is-steam/

What does learning in STEAM look like?

- Intentional connections between learning in Science, Technology, Engineering, the Arts and Mathematics.
- Collaborative planning and adjusted timetabling to allow for intentional connections between disciplines.
- An emphasis on process-based learning.
- Learning that is engaging, action-oriented and connected to real life so that it better prepares young people for life and work in today's world.
- Real-world opportunities for teachers and students to fail, learn from failure and refine their efforts to achieve success.
- Inquiry, critical thinking, creativity, collaboration, communication and innovation.
- A focus on the development of learning dispositions that support cognitive abilities, personal skills and interpersonal relationships.

ABBOTSLEIGH

CRICOS Provider Code 02270F

Junior School
22 Woonona Avenue
Wahroonga NSW 2076
T 02 9473 7700
F 02 9473 7690

Senior School & Administration
1666 Pacific Highway (Cnr Ada Avenue)
Wahroonga NSW 2076
T 02 9473 7777
F 02 9473 7680

www.abbotsleigh.nsw.edu.au