The Winston Churchill Memorial Trust of Australia

2014 Churchill Fellow
Alesha Bleakley

The Northern Districts Education Centre (Sydney) Churchill Fellowship to study the dichotomy in technology education of the future, the role of hand skills and the role of CAD/CAM technology in the production of designed solutions
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-USA, UK, Netherlands, Switzerland, Germany, Finland

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Signed:

Alesha Bleakley
2nd February 2015
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Introduction

Research Objective and Overview

The aim of Technology Education (TE) in Australia is to ensure that all students learn about and work with traditional, contemporary and emerging technologies in order to solve real world problems (Australian Curriculum, Assessment and Reporting Authority, 2013). Globalisation and the rapid pace of technological change are placing greater demands on education and skill development in Australia. As Technology educators, it is the belief of the researcher that it is incumbent to ensure curriculum and skills and knowledge that are being taught prepare students not only for employment in this world, but also the world of the future.

The objective was to look at the dichotomy in Technology Education of the future, the role of hand skills vs the role of CAD/CAM technology in the production of designed solutions.

The program included England, the Netherlands, Germany, Switzerland, Finland and the United States of America. Throughout the course of the study, schools, universities and the manufacturing industry were visited to evaluate how other countries and states are implementing measures to bridge the divide between traditional technologies also being taught here in Australia, and new technologies of the computer aided design and manufacturing skills, from this point forward referred to as advanced manufacturing, that could also be referred to as ‘industry standard’.

As this opportunity led to meeting pre-eminent technology educators from around the world, the experience gained from the Fellowship study proved far broader than the initial research objective. Through relevant visits, exposure was gained to Technology Education curricula in the chosen countries, to understand what the delivery of Technology Education looks like in these countries, to understand curriculum development processes, gain insight into TE teacher training, the roles and responsibilities of professional associations, and gain some insights into the manufacturing industry.

Subject Background

Given the principles it encapsulates, Technology Education is a subject of great worth. However, it could be said that, worldwide there is a lack of understanding about what ‘Technology Education’ means among the broader population. Anecdotally some teachers who teach the subject also battle with the simple underpinnings of WHAT Technology Education is.

Technology Education is often confused with educational technology and technical education in today’s society. It is commonly misunderstood. It is critical at this point to define the difference. Educational technology is where technology is used to aide in the teaching and learning process. The use of computing applications that students interact with to assist in the teaching of a concept would be an example of this. Technical education on the other hand is the term applied to specialist schools and educational programs that focus on the skilled trades and career preparation. This is often also referred to as Vocational Education (Abbott, 2014). The role of Technology Education is not to prepare people for specific occupations. This is the role of Vocational Education. TE is a general education subject area that provides different life long learning opportunities for children.

There are many arguments outlining the lack of identity of Technology Education around the world. One perspective is attributed to the history of the name of Technology Education. Uno Cygnaeus, often referred to as the ‘Father of the Finnish Folk School” was responsible for developing Sloyd, a craft based curriculum, in Finland in 1865 (William E. Dugger, 2010). It was the first of its kind. Sloyd was promoted worldwide and was taught in the United States until the early 20th Century. Gradually Manual Training and then Manual Arts grew as the early years of what is now Vocational Training. Industrial Arts then emerged during the Industrial Arts movement based on the research by Dewey of learning by doing. In 1986 The
International Technology Educators Association, ITEA (now ITEEA) declared a name change to Technology Education (Zuga, 1995).

Some also attribute the lack of identity to the confusion exhibited by the practitioners of the subject (Zuga, 1995). There is a common misconception among the broader population and sometimes even the in-service teachers who have a ‘narrow technological identity’ (Mengersen & Barlow, 2014) potentially leading the public to assign an unintended meaning to the Technology Education subject area.

Technology, as defined by the International Technology Education Association (2007) is “The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants”. Technology Education as a field of study, is where students learn about the process and knowledge related to technology that are needed to solve problems and extend human capability through the manipulation of materials, tools and techniques (International Technology Education Association, 2007). In addition to that many countries around the world have a Design and Technology curriculum. The aim of Design and Technology is to “develop students’ confidence, competence and responsibility in designing, producing and evaluating to meet both needs and opportunities, and to understand the factors that contribute to successful design and production” (Board of Studies, 2009). Design and Technology Education and Technology & Engineering Education are commonly seen as a parallel field to Technology Education in countries around the world such as England (Sanders, 2012).

In Australia education is the responsibility of the individual states and territories. In NSW Technology Education is mandatory from Kindergarten through to the conclusion of year 8. In addition to the mandatory course there are also elective courses in Industrial Technologies, Design and Technology, Textiles, Computing, Agriculture, Marine, Food, and Engineering. This is unique to NSW. The year 2000 marked the year of a national statement following that the development of the current Australian Technologies curriculum began in 2010. The curriculum is currently in the final stages of endorsement by ministers of education.

The Draft Australian Curriculum: Technologies (2013) aims to:

Develop the knowledge, understanding and skills to ensure that, individually and collaboratively, students:

• Are creative, innovative and enterprising when using traditional, contemporary and emerging technologies, and understand how technologies have developed over time
• Effectively and responsibly select and manipulate appropriate technologies, resources, materials, data, systems, tools and equipment when designing and creating products, services, environments and digital solutions
• Critique and evaluate technologies processes to identify and create solutions to a range of problems or opportunities
• Investigate, design, plan, manage, create, produce and evaluate technologies solutions
• Engage confidently with technologies and make informed, ethical and sustainable decisions about technologies for preferred futures including personal health and wellbeing, recreation, everyday life, the world of work and enterprise, and the environment (Australian Curriculum, Assessment and Reporting Authority, 2013).

The world needs people with the ability to think critically, be creative, create innovative design solutions and be willing to take risks (ACARA, 2013, Wagner, 2012). The Draft Australian Curriculum: Technologies emphasises this, as do the state and territory curricula currently implemented in Australia. Wagner suggests that all students should be aiming to be ‘innovation ready’, rather than ‘college ready’ to prepare them for a rapidly changing world. In Australia, Technology Education is a fundamental curriculum for all students, regardless of learning levels, career choices, or life aspirations. “Tomorrow belongs to those who effectively and creatively interact with technology today and dream of its possibilities for tomorrow” (The Technology Education Lab, 2013).

Given the changing nature of the world around us to a more technologically diverse environment it is only natural that the materials, tools and techniques that were once the main focus of Technology Education have changed. The manufacturing industry along with engineering, medicine and many more areas of human endeavor are now utilising more advanced forms of manufacturing and control technologies to solve the changing needs of today’s society. As a result Technology Education is focusing more on
computer aided design and computer aided manufacturing (advanced manufacturing) as the tools to produce solutions to ‘real world problems’. In the recent years technologies such as additive and subtractive manufacturing along with laser cutters and 3D scanners have started to become the ‘norm’ in the Technology Education classroom. This change often leads to people asking if there is a place for hand skills and traditional technologies in the classroom creating a dichotomy in Technology Education for the future.

Research Overview

The Churchill Fellowship empowered the researcher with a wealth of knowledge and experiences, which have given a holistic understanding of Technology Education, and are sufficient grounding for future research and work in this area. The ultimate goal is to have a positive impact on the future of Technology Education in Australia.

Acknowledgements

I would like to acknowledge and sincerely thank the Winston Churchill Memorial Trust and the Northern Districts Education Centre for awarding me this opportunity to undertake my research.

I would like to thank Mrs Ruth Thompson 1998 Churchill Fellow and Mr Peter Thompson Inspector, Technology Education at the Board of Studies Teaching and Educational Standards, for encouraging me to apply to the Churchill Trust. I would also like to thank Professor Howard Middleton, Mr Russell Cooper and Mr Paul Phillips for supporting me in the application process and during my study.

I am appreciative of all the individuals who took time out of their busy schedules to meet with me and support my research. Special thanks are due to Professor Kay Stables, Mr Tony Lawler, Mr Ken Walsh, Professor Marc De Vries, Mr Aki Rasinen, Ms Sonja Virtanen, Mr Steve Barbados and Emeritus Professor Mark Sanders for the generous amount of time they spent organising visits, connecting me with schools and working on my behalf to help organise an informative and diverse range of visits suitable for my study.

I must also acknowledge the support I have received from my principal Mr Gary Johnson, from the NSW Department of Education and Communities who kindly allowed me special leave privileges to undertake my research. My thanks also to my colleagues from Cherrybrook Technology High School and my Technology Education colleagues from throughout Australia.

Finally I would like to thank my partner Alec Draffin, my family and friends for their ongoing support.
Executive Summary

Ms Alesha Bleakley
Teacher- Cherrybrook Technology High School
Address: 59/27 Buckland St, Chippendale Sydney NSW 2008 Phone: 0423522734
Email: aleshableakley@hotmail.com  alesha.bleakley1@det.nsw.edu.au

Project Description:
The aim of the Fellowship was to investigate a dichotomy for Technology Education of the future, the role of hand skills and the role of CAD/CAM (advanced manufacturing) technologies in the production of designed solutions. Throughout the duration of the study a range of schools, universities, academics and manufacturing industries were visited to gain an understanding of the state of Technology Education in England, the Netherlands, Germany, Switzerland, Finland and the United States of America.

Highlights:
• Gaining an understanding of the development and revision of Technology Education curricula around the world.
• Gaining insight into the content and main focus of TE curricula internationally.
• Meeting Professor Marc De Vries, Delft & Eindhoven University. Marc is also the editor-in-chief of the International Journal for Technology and Design Education. Marc is exceptionally knowledgeable regarding the state of Technology Education around the world.
• The European Manufacturing Summit, Dusseldorf Germany provided access to a number of highly successful manufacturing companies from Europe, as well as a variety of manufacturing research professors. This conference discussed the concept of industry 4.0 and the current state of European manufacturing.
• The International Technology and Engineering Educators Association (ITEEA) in the USA were critical in gaining understanding of Technology Education in the various states. Their contacts and support enabled access to school visits and valuable information. Discussion with Emeritus Professor Mark Sanders, Virginia Tech University, was highly informative and provided insights regarding America’s push towards integrative science, technology, engineering, and mathematics (STEM) education.
• Attendance at the International Manufacturing Technology Show, Chicago provided insight of the nature of the global manufacturing industry and its future directions. Furthermore highlighting the importance of Technology Education and the skills sets that are required to teach future generations.
• Mr Aki Rasinen and Ms Sonja Virtanen for providing insight into the history of Craft education in Finland

Themes and Conclusions
• To be able to best equip students for the future, teachers need more support and appropriate professional development in 21st century Technology Education.
• The state and national professional teachers associations for Technology Education need more support from government, curriculum authorities and appropriate bodies to ensure they can provide useful, accredited professional development for Technology Education teachers.
• The support of professional associations is critical for the success of teachers in the Technology Education discipline.
• It is critical for students to be learning about advanced manufacturing techniques to prepare them for the world of the future. There is a need for an appropriate balance of both advanced manufacturing and traditional hand skills. This should be seen in the Technology Education curricula.
• The skills developed through Technology Education are transferrable and critical to create a generation that is capable of solving the problems of the world they live in.

Dissemination
The information acquired in this study will be used in classroom teaching. Articles will be written for journals. Meetings will be held with Technology teacher associations and presentations will be delivered at relevant conferences potentially leading to the provision of professional development opportunities for colleagues.
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Main Body

Part 1- Technology Education for Students

The fellowship itinerary included school visits in England, Finland, Germany, the Netherlands and the United States of America. Not all countries refer to their curriculum as Technology Education. Therefore it is important to note from the outset that England have a national Design and Technology curriculum, Finland have a national Craft curriculum, Germany have various Technik curricula dependent on the state, The Netherlands have an integrated approach to TE and the USA have individual curricula for their states and districts. However, they also have National Standards for Technological Literacy developed by ITEEA.

England

An overview of England's schooling system

"Compulsory schooling is divided into four Key Stages. Key Stage One (grades 1-2, ages 5-7) and Key Stage Two (grades 3-6, ages 8-11) concentrate on English, mathematics, science, design and technology, information and communication technology (ICT), history, geography, art and design, music, and physical education. In Key Stage Three (grades 7-9, ages 11-14) and Key Stage Four (grades 10-11, ages 14-16), citizenship and modern languages are added, with one language required" (Rasinen, 2003).

After Year 11, students then choose if they would like to continue with their education in school. If they choose to stay on in school (which most do), they proceed to Key Stage Five (Grades 12-13, ages 17-18). It is also important to note that students must stay in some form of education or training until they are 18 years old.

The different models within the English schooling system include:

- **State Funded Schools**: State schools are school systems that provide education to 3-18 year olds free of charge. They make up the majority of the English schooling system.

- **Academy**: Academies are government-funded schools, however they are independently controlled, meaning the school manages all of the funding which results in them having more autonomy. They are NOT controlled by the local authority. An application needs to be made in order to attain Academy status. This also means that they have more freedom to adapt the National Curriculum – some don't teach it.

- **Free Schools**: Free schools were an initiative that started in 2011 by the Gove Government. Free schools are established by charitable groups such as parents, education charities and religious groups. The schools are not-for-profit and government-funded. They are free to attend.

- **University Technical Colleges**: University technical colleges (UTCs) are government-funded schools that offer 14–18 year olds an education with a high focus on STEM based subjects. They are free to attend and generally have a link with a university and industry sponsors. There are 30 of these country-wide.

- **Private / Independent Schools**: Private/independent schools are schools that are privately maintained. Fees are paid by parents. These schools are also sometimes referred to as “public schools”. These independent schools do not have to follow the National Curriculum. There are about 2400 of these schools in England.

**OFSTED**

OfStEd is the Office for Standards in Education, Children’s Services and Skills. They report to Parliament and are independent and impartial. They inspect and regulate services which care for children and young people, and those providing education and skills for learners of all ages. State schools and some
independent schools are reviewed by OfStEd every three years at which time they publish the results of the school review online.

Curriculum

Design & Technology

England has a National Curriculum for Design and Technology. The most recent revision of the National Curriculum was conducted in 2013 and implemented in September 2014. There is a national curriculum for Key Stages 1, 2 and 3 and it is mandatory in all 3 stages. The document is currently 3 pages, in comparison to Australia’s 108 page document. Due to the structure of England's schooling system approximately 50% of schools have to follow the national curriculum.

The purpose of study for the National Curriculum Design and Technology in England is as follows: “Design and technology is an inspiring, rigorous and practical subject. Using creativity and imagination, pupils design and make products that solve real and relevant problems within a variety of contexts, considering their own and others’ needs, wants and values. They acquire a broad range of subject knowledge and draw on disciplines such as mathematics, science, engineering, computing and art. Pupils learn how to take risks, becoming resourceful, innovative, enterprising and capable citizens. Through the evaluation of past and present design and technology, they develop a critical understanding of its impact on daily life and the wider world. High-quality design and technology education makes an essential contribution to the creativity, culture, wealth and well-being of the nation." (Department for Education England, 2013)

The subject content for the National Curriculum is organised into four sub headings: Design, Make, Evaluate, and Technical Knowledge. It is also important to note that cooking and nutrition outcomes are separate.

An additional change that has also been implemented as a result of the national curriculum revision for Key Stage 1 & 2 is assessing without levels. This allows schools and teachers more flexibility in the way they plan and assess their students. From the experience in schools during this trip some teachers like this development, while others are not so positive. It is the researcher’s opinion, that at this stage in the student’s development there are more benefits for students and teachers alike. Most schools are keeping the levels that were in place in the previous document because they feel it is good to have something for the students to work towards. Others are mapping out new levels that are suitable to their circumstances. As there are no external assessments in these levels for the national curriculum therefore it is the researcher’s opinion that it is not necessary to have them.

School Visit Summary

Six schools and three UTC academies were visited during the time in England. Qualified teachers teach Design and Technology in England, and technicians also support the D&T classroom. During the visits to schools it was evident that the technicians played a crucial role in supporting the teacher and the students. The number of technicians in schools varies according to the number of D&T staff, and the amount of students in the school. East Barnett School, the largest school that visited had an enrolment of 1350 students. There were 15 D&T staff and 5 technicians. Whereas at King Edward VI Five Ways there were 2 teachers and 2 technicians. The technicians completed a range of roles from timber preparation through to one-on-one supervision of students using machinery. They were responsible for ordering equipment and materials, and planning projects with the teachers. Depending on the school, some technicians were trained in the use of advanced manufacturing equipment and played a critical role in the classroom when it came to the use and maintenance of this machinery. Ladybridge High School was a good example of this. The technician spent a large proportion of his day assessing CAD files and running jobs on the laser cutter and 3D printers. It was indicated that the use of the machinery, in this instance, hinged on the ability of the technician. It was also evident that having the technicians available in the classroom allowed the
teachers to focus more on quality pedagogy. The knowledge and understanding of the technicians in the classroom is a true asset to the D&T area of study.

The schools visited included public, private, academies and University Technical Colleges. In all of the schools visited, the teaching of manual skills, CAD and CAM were evident. In all schools visited there were laser cutters and 3D printers. In some schools there was additional equipment such as CNC milling machines, vacuum formers and 3D scanners. In addition to these pieces of machinery there was an array of traditional tools and machinery. The use of CAM machinery varied. There were three independent variables that contributed to the use of the CAM machinery:

1. Teacher training
2. Time it takes to use the machine in a classroom setting
3. Material expense

In some of the schools visited the available machinery was not utilised because the teacher did not know how to use it and/or they felt they had not been given adequate training to feel confident in using it in a class setting. In some cases this was alleviated because the technicians would be capable of using the machinery. The larger issue in this instance was that it wasn’t used therefore the student would not be taught how to use the machine independently.

Time was often raised as an issue. The models of CAM machinery used in schools are generally limiting in terms of size and power capabilities. Because of this, teachers indicated that they struggled to maintain class projects that utilised the machinery because with 25 students in a class it was not practical to run a whole class of 3D printed projects given the time it takes to 3D print or laser cut a whole class of projects. Some schools did not find this an issue, namely King Edward VI Five Ways, Dixons City Academy and Ladybridge High School. In these cases the use of a technician was critical to the success of the projects they were running. Projects were often printed or cut outside of class time. The machines would be running all day.

Some schools did have issues with the cost of the materials required to run the machines. Particularly when it came to 3D printing. The specialised plastics required were often an expense the department decided it could not justify given the size of the project that was produced.

The development of CAD skills, and the associated software utilised, varied in each of the schools visited. In most cases for 2D work the software of choice was 2D Design, a program designed and developed by TechSoft. 3D modeling software varied in each school, generally due to teacher capabilities. Most used Autodesk, whilst others used SOLIDWORKS, Pro Desktop, Creo or Google SketchUp. All of the schools visited utilised some form of CAD and the students could demonstrate proficiency in using it. It was interesting discussing the use of CAD software with teachers, as many indicated that students often found it harder to communicate their ideas with hand-drawn sketches than they did using the software available.

Traditional skills were still the principal skills being taught in the classroom, particularly in KS3 and KS4. In this regard, the machinery students were being taught to use was on par with what is being taught in NSW classrooms. The amount of classrooms and the diversity of the tools and machinery varied depending on the subjects offered at the school. For example at Saint Saviour and Saint Olaves, these schools had very traditional wood-based workshops that were also utilized for acrylic work. Whereas Dixons City Academy and East Barnet (both Academies) had a variety of materials specific rooms.

There were some commonalities in the projects being taught across schools. Some common examples include laser cut De Stijl clocks or mirrors, and laser cut key rings. Common traditional projects included footstools, marble runs and electronic skills testers. The King Alfred School was a unique experience. It had a forge at the back of the D&T building and it engaged some classes with very traditional forge metalwork.

Some of the feedback obtained from teachers relating to the use of CAM was that they tried to have a small CAM based project in KS3 so that students were introduced to the concept. However, project work
tended to focus more on the acquisition of manual skills in the early Key Stages, and then advanced manufacturing would be focused on in the later years as an option in individual project work. Advanced manufacturing was often seen as a value added skill to ensure that traditional skills were not eliminated from the technology classroom as teachers still see the value in nurturing these skills for problem solving.

The value of Technology Education in the schools visited was highly dependent on the staff and history of technology in the school. Some schools that demonstrated high value for Technology Education included East Barnet and Dxicons City Academy. In both of these examples some of the staff were also involved in D&T outside of the school environment, such as curriculum development, professional associations or exam boards. Notably, at East Barnett students in KS4 have to mandatorily elect a technology based subject. This was unique to this school.

In England OfStEd has a large role to play in holding schools and training institutions accountable for the quality of the teaching and the learning taking place. One of the elements in their assessment of schools is the percentage of A* to C grades achieved by students in each subject at the GCSE and A Level. As a result, teachers are frequently pushing students to perform to the best of their ability to reach this grade range. It was indicated to me during my school visits that in order for students to achieve a grade at the A or A* level in these external assessments they need to demonstrate the ability to use advanced manufacturing processes throughout the design and development process of their projects. This is common knowledge amongst the D&T community, and as a result is pushing teachers to become more proficient in the use of this equipment.

University Technical Colleges Summary

UTC are government-funded schools, that are similar to Academies in that they have autonomy. UTCs are a relatively new initiative - the first UTC opened in 2010. There are now 30 in England with another 30 set to open by 2016. This model of schooling is aimed at specialising in STEM based subjects where there is a shortage of STEM based skills in industry. These include: Engineering, Manufacturing, Health Sciences, Product Design, Digital Technologies and the Built Environment. The UTCs work closely with a university, local employers and industry partners.

The UTC is designed to be a mature, industry-based learning environment. Students cannot move to a UTC until Year 9 meaning they need to complete 2 years of high school at another institution first. The uniform is business attire. It was a general observation that teachers in other schools are not very supportive of this model of schooling. The general view is that at the age of 14 students are too young to be moved into a specialist model of learning that is often perceived as 'limiting'. Other criticisms are that the government has invested millions of dollars into the development of these schools, which has taken funding away from other schools.

The UTCs are purpose-built for a maximum of 600 students (150 per year group). The foundation of the UTCs is that they are to have a partnership with a university and also industry partners. The idea is that students are to get more ‘on the job’ experience and also develop pathways to the universities for tertiary training. Three UTCs were visited during the time in London. Each of the UTCs that visited offered different subjects and there appeared to be varying beliefs as to whether the UTCs purpose was preparing the students for university, or if they were preparing them for apprenticeships.

The learning environment for the technology and engineering based courses offered at the UTCs are generally open plan with benches or partitions dividing the floor to isolate different learning areas. It looks more like an industrial workshop rather than a classroom. The UTCs also have technicians on-site.
The subjects on offer were dependent on the UTC, however the main focus is STEM based subjects. As a result, students are required to take subjects such as Engineering and/or Computing Science. To provide some examples, the Leigh UTC offered: BTEC Engineering, English, Maths, Science, Additional Science and Computing Science. In addition, they can elect to take either: Art & design, Product Design or Systems & Control. Greenwich offered Resistant Materials, Product Design, System and Control, Graphic Design, Electronics, Art. Aston offered English, Maths, Science (triple science or core + additional), History, French, PE, Engineering (compulsory), GCSE- Product Design, Computer Science, Electronics. In addition to the mandatory and elective based courses each of the UTCs offered extra curricula or choice engineering based subjects or projects such as; VEX robotics, F1 in schools or Mars Rover Challenge. The purpose of these choice activities is to develop skills in context.

The sponsorship from industry partners was unique to the UTCs. Each school is supported by major sponsors who provide funding for equipment, as well as support to teachers for machinery. Sponsors include: Kennards, Autodesk, VEX Robotics, Mitsubishi, Network Rail, Sterling Power, Eon, Morgan Ceramics, Festo Del Cam, Mazak. Whilst these companies do not donate money they have various involvements with the school. E.g. they donate tooling and machines. Facilities are high tech and all included laser cutters, CNC milling machines, 3D printers, and a variety of other industry based CAM machinery. High quality CNC equipment appears to have been purchased and installed into these establishments yet teachers do not necessarily know how to use it properly, or understand the role of the machinery in an industrial context which means the students may not get to learn how to use them. Another potential issue is that when students go to work placements (which are compulsory) they are not permitted to work on machines. They can only shadow or work in the office because they do not have the necessary qualifications to practice their practical skills.

Autodesk was the software package of choice in the UTCs visited. Autodesk has an agreement with all of the UTCs. There appears to be an intense focus on engineering drawings and the importance of them in industry, therefore in all of the visits I had the schools were teaching CAD skills to their classes.

There are identifiable workshop areas such as: Machining bays, wood working areas, welding, outdoor bricklaying areas, fully equipped electronics room as well as several computer labs. The development of manual skills was the most predominant focus in all of the UTCs. One of the UTCs was unique in that they also still offered traditional technical drawing. Their belief was that they should not learn CAD skills without the traditional skill set.
The Netherlands

Professor Marc DeVries

Professor DeVries is an invaluable source of information when it comes to TE around the world.

"Marc J. de Vries is professor of science and technology education at Delft University of Technology, affiliate professor of reformational philosophy (of technology) at the same institute and assistant professor of philosophy of technology at Eindhoven University of Technology. He serves as the editor-in-chief of the International Journal for Technology and Design Education. He is the author of "Teaching About Technology", an introduction to the philosophy of technology for technology educators. He is also responsible for the Pupils’ Attitude Towards Technology international conference series."

Technology Education in the Netherlands

Schools in The Netherlands are split into the following levels: Upper secondary 16-18 (several school types 2 year or 3 year options) 18 is considered pre university. Lower secondary 13-15, Primary 4-12.

“The Technology Action Plan for The Netherlands was implemented during 1993 to 1997 for primary schools (pupils aged 4 to 12). Financed jointly by the Ministries of Education, Culture and Science, and Economic Affairs, the purpose was to stimulate attention to technology within and outside primary schools. At this time importance was given to combining thinking with doing” (Rasinen, 2003).

In primary school TE is integrated into other subjects. There were several attempts to increase the focus of TE in primary after the implementation of the Technology Action Plan. In the mid 2000's schools were given money under a program titled VTB which was a large retraining program for teachers. The government implemented this and generalist primary teachers were retrained for a short period of time. This was a sophisticated program that taught teachers about the philosophy of science and technology. This program, in turn, converted the primary teacher’s views about science and technology in the curriculum. Substantial momentum was gained through the program for TE in primary education. There was a view to follow up with more school-based activities. However, there has now been a 5-year gap and this has not happened. Some universities have been given funding for additional research. Primary TE is now very fundamental resulting in minimal practical application. There are now centres that were provided funding for teacher support. Delft has some of this funding and they do activities with teachers and students. TE activity is slowly increasing in Primary schools.

In the lower secondary system TE was implemented as compulsory from 1993. The universities did some interesting things in terms of teacher training and curriculum development at this time. When developing the curriculum the Netherlands took design elements from the UK curriculum and a critical approach from Germany. A series of textbooks were also developed in support of the curriculum. Professor deVries was involved with these developments. It took a while for the Netherlands to develop their own research. After 10 years the government decided that it was sensible for schools to integrate TE into the science curriculum. Most schools chose this as an option as it was easier for the timetable and for funding purposes. They also had doubts about the status of the TE curriculum believing that it had a low status. The irony is that in the school with a strong TE faculty gained from the merger because they were now considered to be on par with science. As a result D&T teachers gained support from this and the subject strengthened in the school. Some schools still have TE as a stand-alone subject, although this number is decreasing.

The attainment targets for TE students are still the same as having TE as a standalone subject in the curriculum, and they are still mandatory to reach. 1998 was the last revision of these attainment targets. There is no national exam for these targets.
Germany

German Schooling system

The structure of the German schooling system is quite complex in a variety of ways. It is widely understood that students choose at an early age if they want to pursue a vocational training path or one that will lead them to study at university. It is debatable if this is the reason that Germany has such a strong manufacturing history. There is a 'culture' of manufacturing in Germany and this is strong. On the flip side of that they are still in need of more engineers. Just like the other countries visited.

Students attend primary school until the end of year 4. Years 5-10 are referred to as Secondary 1. At the end of Year 6 students sit an exam called the Erprobungsstufe to determine if they will be pursuing a vocational route of schooling (Realschule) or continuing into a Gymnasium (school that prepares them for university). Students sit an exit examination at the end of year 10 in preparation for proceeding to Secondary 2. The exit examination for Germany is called Abitour. Students sit exit exams in 4 subjects; mathematics, foreign language, 1 science and German.

Technology Education in Germany

There are 16 different states in Germany. All have their own version of a Technology Education curriculum. There is no national framework. There is some attempt to keep the standards the same in each state but it is difficult. TE in primary generally takes place within social sciences, there is no separate curriculum. Whilst there is a large focus on STEM in other countries in Germany they do not talk about STEM, they have their own version called MINT- Maths, IT, Natural sciences and Technics. There is a national MINT association

School visit summary

Due to the timing of the trip to Germany and the states visited there was only 1 school visit. However, the contact was also a curriculum developer which helped in gaining insight into the state of TE in Germany and also about the state of Nordrhein- Westfalen specifically. IST Bochum is a Gymnasium for student's grades 5-12. The school is well resourced for TE. Almost all of the equipment is portable and purpose built for schools. The materials used are basic plastics with a large focus on electronics. There are 3D printers in the school and a laser cutter. The school has a LEGO Education Innovation Studio in the school library. The librarian is also trained to deliver LEGO courses.

TE was introduced in Nordrhein- Westfalen in 1980. The most recent revision of the Technik (Technology) curriculum was in 2014. Klaus Trimbourn was the contact made in this school and he was one of 3 who developed this curriculum. TE hasn’t been a very strong subject in Germany, however in 2006 the Minister for Innovation contacted Klaus to start strengthening TE. In 2006 IST Bochum was the only school offering TE in the area now there is an even spread across the state. There are now 4 schools in the area offering TE in grades 10, 11, 12 and four additional schools send their students to these schools. 8 in total means that700 students in the area doing TE at higher levels. TE is now reaching 5000 students in the area each year. Most schools are not equipped with a workshop so it is not mandatory to address this curriculum if you do not have the resources. Only if you have the workshop do you need to follow this curriculum.

Finland

Curriculum; Craft

Finland has a strong history of Craft education. It began in 1866 with 'Girls Craft' and 'Boys Craft'. In 1970 this changed to Textile work and Technical work, and since 1994 these 'crafts' were merged under one structure called 'Craft'. In 2004 there was a stronger emphasis on Technology Education and there was a proposal to change the name at this time, however, it was overturned. One focus the curriculum did have was a stronger push to be considered as 1 subject where boys and girls did not choose their subject rather they had to complete both textiles and technical. This has not really been carried out. New curriculum for 2016 is pushing for this change to become the 'norm'. The Finnish curriculum also includes cross curricula
themes in grades 1-6. These are: Growth as a person, cultural identity and internationalism, media skills and communication, participatory citizenship and entrepreneurship, responsibility for the environment wellbeing and a sustainable future, safety and traffic, human being and technology.

Aims of the 2014 revision of the TE curriculum is: focus on technology, individual relationships and to see the importance of technology in our daily lives, understand technology its evolutions and impacts, to take the position on technological choices ethical and responsible use of technology, the use of ICT.

Finland is in the process of revising its National Curriculum for implementation in 2016. It roughly translated to;

2014 DRAFT Craft curriculum General statement for years 1-9

- Guide pupils to understand the whole craft process
- Must use various materials
- Activities of design should be expressed through making and the use of technologies
- Students can design, create and evaluate individually or in groups
- Projects should be investigative, inventive, encourage trial and error, visual and technical solutions should be developed in different materials. Problem solving is critical
- In Craft students learn to develop and apply different technological skills
- Working with their hands designing skills and creativity are developed
- Starting point in crafts should be theme-based and should be cross curricula incorporating cross curricula themes
- Empower students to be responsible citizens. This should help them to understand their culture and heritage and also recognise and understand the culture of others
- Craft will raise ethical, responsible and participative citizens who evaluate themselves. They will have the skills to sustain, develop and express themselves through making.

School Visits Summary

Six schools were visited during the trip to Finland. Two of these schools were in the North in Oulu, three in the middle of Finland in Jyvaskyla and one in the South in Helsinki. Finland is going through a period of change at the moment and the trend is for schools to change from a year 1-6 and a 7-12 structure to a 1-9 and a 10-12 structure. The lower secondary school visited will be changing to a 10-12 school in 2 years’ time with a brand new 1-9 school that is currently being developed. Technology Education is not offered in the senior secondary years (10-12).

Upon visiting both the primary and the lower secondary schools it quickly became apparent that advanced manufacturing was not a focus in Finland. Of the six schools visited, only one had a piece of advanced manufacturing equipment. Two of the schools had a small amount of computers that were capable of being used for CAD functions. Latokartano School in Helsinki had a CNC milling machine in one of its Technology classrooms and also a vacuum former. It was indicated that this machinery was not used because the teachers had not been provided with the training to enable them to feel confident to use it. The school was six years old. In a newer school Mankolan Koulu located in Jyvaskyla, which was two years old, there was a very small computer room with six computers designed to be a CAD room. The school had no advanced manufacturing equipment. Some of the other schools visited were attempting to integrate educational technology into the classroom such as iPads. However, these were not utilised in the Craft
area of study and the schools were facing issues with this type of integration as they do not have Wi-Fi available.

It was evident from visiting the schools and also researching the history of Technology Education in Finland that their history of Craft education is the underlying premise of the current curriculum. Whilst the new draft Craft curriculum is in the process of being developed, from the documents read there is still no reference to the use of advanced manufacturing equipment or the study of emerging technologies. This results in traditional skills and techniques being taught in the classroom. Although there was a lack of advanced manufacturing equipment in the schools visited, they were exceptionally well equipped with traditional equipment. Some of the workshops that visited during the time in Finland were some of the best experienced. Their workshops were generally mixed materials based with flow-through areas so that the products completed by the students could incorporate multiple materials and techniques. It was indicated that during the development of the buildings the technology teachers were often involved in the planning and developing stages enabling the designs to be very functional. In Finland the funding for schools comes from the City rather than the federal government. (as it does in the USA!)

The project work that was being completed by the students had a traditional materials and hand skills base in the younger years. As the students got older and potentially elected to undertake further study in the Craft area, their projects developed more into a design and development style project. Due to the strong history of Craft education, it is still common for teachers to work from project specification sheets with their students leaving limited room for creativity and innovation. There were some exceptions to this. At the Merikoski school students are encouraged to design and develop their own projects from year 7. This was also demonstrated at the Lintulampi School. This school was evidence of exceptional practice. Mika taught students from year 3-6 and they would all design individual projects with mixed materials from Year 3. Their projects included designing, planning and creation of the individual projects, inclusive of electronic circuits.

One of the most notable differences about Finland compared to anywhere else was TE in the primary years. Each of the schools that attended that had primary students was fully equipped with hand skill based workshops. This is unique to Finland. The workshops are equipped to the same standard as a high school in Australia. This is not a design feature of primary schools in Australia. Whilst this is the case in the schools visited from speaking with teachers and academics whilst in Finland it would appear that these workshops are sometimes taught by specialist Craft teachers and sometimes they are taught by classroom teachers at the primary school level. Every primary school teacher undertakes training in Craft education so they are all qualified to teach it. Similarly to other subjects in Finland (because they don’t assess until year 10) there are no formal assessments for any level in Craft.
America

American schooling system

The United States of America has 50 different states, every state has its own version of a curriculum for each subject. Districts can develop their own curriculum, too. Nationally developed standards in the US have been produced over the last 20 years and they give better insight into what students should know and be able to do in order to become technologically literate. These standards have influenced the direction and progress at a national, state and local level since the late 1980's. There are public and private schools in the USA, 88% of students attend public schools. In most cases Elementary schools cater for students in years 1-6. Junior high is year 7-9 and senior high 10-12 (National Centre for Education Statistics, 2014).

TE in America

The International Technology Education Association received funding from the National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) from 1994-2005 to develop Standards for Technological Literacy (STL) (International Technology Education Association, 2007). Many states and local school districts use the STL to develop their own state based standards and curriculum, but as a result, each state has different TE curriculum. The STL is the only document developed to try to standardise Technology Education in America.

The International Technology and Engineering Educators Association (ITEEA formerly ITEA) is the national professional association for technology, innovation, design and engineering educators in America, although they are an international organisation. ITEEA define Technological Literacy as one’s ability to use, manage, evaluate and understand technology (International Technology Education Association, 2007). Technological Literacy can be viewed as furthering the study of technology, innovation, design and engineering. Technological Literacy is seen as the capacity to understand the broader technological world than the ability to work with specific pieces of it. Each state also has its own TE teacher association.

While these standards are in existence and for the most part teachers are familiar with them, it was the opinion of the academics and research personnel visited that these standards are in fact not always the basis for curriculum in schools. To add to the disparity, each state is broken into counties and districts. Different groups or individuals govern each county. As a result there are a variety of different approaches to TE in each county. It was difficult to make a general comparison between the states and schools visited due to the inconsistencies demonstrated between each of the states and counties. It is not uncommon now for a school in the US to not have any workshops. Quite often during the visits they would refer to these rooms as ‘dirty labs’.

School Visits Summary

During the time in America seven different sites in four different states were visited. Some sites had multiple schools on the same campus. In total, six high schools and three primary schools were visited. Of the schools visited it became obvious that the integration of Science, Technology, Engineering and Mathematics, referred to as STEM was a major focus of TE in America. The term STEM, originated in America. Judith Ramaley (2001). Judith was a director at the National Science Foundation. Her concept for STEM was that science and math would be the bookends but the core focus of her vision was in the middle. Sadly it hasn’t really turned out that way and has turned out to be more like SteM. This is attributed to America’s major focus on common core such as science and maths that have rigorous assessments. There are no assessments for TE. As such TE does not appear to be as valued.

The status of TE in the schools visited varied. From the schools with the most value for TE where the school was developing and implementing successful STEM focused subjects that did in fact incorporate and focus on elements of Science and Mathematics as well as problem solving through Technology and Engineering. The primary and lower secondary schools appeared to do this far more effectively than the upper
secondary schools. A high school example of best practice was The Ellis School. The Ellis schools is a K-12 school for girls that incorporates STEM based philosophies to encourage their students to use innovative and creative problem solving skills in project based learning for most subjects in their school from K-12. The other example of exceptional practice was South Fayette Schools. South Fayette is a school district that has four schools at the one site (intermediate, elementary, middle and high school). The intermediate, elementary and middle school all demonstrated exceptional practice of STEM education. There was a large focus on integrating the STEM subjects and a large focus on project based learning. The schools were all well equipped for basic experimental/ prototyping style products. However, they were not workshops. This type of space was unique to America.

All of the schools visited had at least one 3D printer. Norwin High School, Robinson Secondary School and West Springfield also had additional advanced manufacturing machinery such as milling machines and laser cutters. This type of equipment was found in the high schools, not the primary schools. In addition to this machinery the high schools were also very well equipped for multimedia based courses and activities with most having media labs for a daily radio show and commentary.

The most common software being used in the high school was AutoDesk suite. This was not being used in primary schools. Most of the high schools had CAD classes and they were often full. Some also offered advanced CAD classes. This was perceived as a valuable skill for the future. As mentioned previously quite a few of the high schools that visited did not have traditional style workshops. These had been replaced with computer labs with small machining bays suitable for prototype development. As such advanced manufacturing courses, robotics, media, architecture and Design and Technology would often be run as a product prototype based course out of a computer lab.

The schools that did have workshops would offer courses such as Electronics, Manufacturing, Energy Power and Transmission, Design and Technology, Engineering, Automotive, STEM Advanced Engineering, Aerospace Science, Engineering Systems. These classes would only be an elective in senior high school and would have students from year 9-12 in the one class. The only time traditional hand skills were witnessed being taught was in a manufacturing class and in an engineering class that were making Co2 cars. Only one manufacturing class was seen as there was only one school equipped to offer it based on the small sample.
Part 2- Technology Education/ Professional Development for Teachers

During the planning phase of the Churchill fellowship professional associations and universities were a point of contact for making classroom connections and determining the best people to visit. Technology Education researchers are a close community and are well connected. Both professional associations and universities have key roles to play in the training of Technology Educators for advanced manufacturing technologies.

England

Universities

There are three universities in England that provide undergraduate and postgraduate education for Technology Education teachers. During the time in England two of these universities; Sheffield Hallam and Goldsmiths College, London University were visited.

Goldsmiths

The first meeting was with Professor Kay Stables (Program Leader, Graduate Diploma in Design, Co Director TERU (Technology Education Research Unit)) Department of Design Goldsmiths College, University of London. Kay was part of the recent review of the National Curriculum. Goldsmiths College London University has been educating teachers since the early 1990's. Goldsmiths is well renowned for its teacher training and has one of only 3 Design & Technology (D&T) teacher training facilities left in England.

Training for practical subjects is delivered through the Design faculty, and allows students access to work with design lecturers and their specialist knowledge. From a brief tour of the campus it was evident that the students (future teachers) were being taught traditional technologies and techniques as well as advanced manufacturing. The university had a diverse range of advanced manufacturing technologies and provided students with the necessary skills to competently deliver both skill sets.

Sheffield Hallam

Sheffield Hallam is the largest provider of Technology Education teacher training in the country. I toured the campus with Rowan Todd the leader of the Centre for Design and Technology Education. Rowan explained the nature of the courses that they ran for their D&T teachers and the alternative pathways people can take to become qualified to be a D&T teacher. The tour displayed the extensive facilities that the university has to cater for its design courses. These facilities and teaching staff are also utilized for the teacher D&T courses. As such the skills and techniques that are taught to the students should be sufficient for them to use and implement in the classroom.

Whilst these universities are well equipped for undergraduate and postgraduate courses in Technology Education they appear to provide little to no support for ongoing professional development. Therefore, teachers who have been in the system for a long period of time may not have been exposed to the training and development opportunities in relation to newer technologies. This is where the professional association plays a crucial role. It is important to note; continual professional development is not mandatory in the UK for teachers.
Professional associations are defined as:
“A body of persons engaged in the same profession, formed usually to control entry into the profession, maintain standards, and represent the profession in discussions with other bodies” (Collins English Dictionary, 2015). The main body for D&T educators in England is The Design and Technology Association (D&TA). The D&TA is the professional association representative of design and technology teachers in the UK. They have approximately 6000 members made up of mainly secondary teachers, including 1000 primary. The D&TA is an independent charity. It gives the following benefits to its members: monthly e-newsletter, D&T Stream, advice, information and guidance on educational and curriculum issues, access to local branch networks, access to expert consultants for D&T advice. They continue to run advanced manufacturing training to teacher and also run a summer school program through Loughborough University. Networking opportunities via active social media channels for discussion and sharing of ideas, advice, information and guidance around important educational issues, curriculum credits.

D&TA have developed a relationship with Government and its agencies that contact the D&TA regarding the subject and any proposed changes to curriculum. Their opinion is valued in curriculum development.

In addition to these benefits to their members they also support some very important teacher networks that encourage problem solving and networking among TE teachers. Whilst these avenues are a more informal approach to a traditional course, the information and help available to the TE teachers through social media platforms such as Facebook have become critical to the success of advanced manufacturing based design projects in the UK.

Another not-for-profit initiative developed to help modernise and improve D&T in the UK is Teach Design. Teach Design publishes a magazine, an annual conference, they have a LSEF program with the London Mayor office, teach meets, and some general social media work. They also have Tech Centres across the UK that are used for professional development courses and support for teachers. Some of their professional development includes 3D printer training, CAD training, robotics etc.

ICSAT, which stands for: Inspirational curriculum support, advice and training is a ‘Hands-on’ training company with the express mission to provide inspirational support, advice and training for classroom practitioners and students, which supports and develops high quality classroom experiences and outcomes from KS1 to KS5, in D&T and Computing/ ICT. The company was started in the last two years by three retired teachers to provide more support for teachers and students. They run training courses and a variety of workshops for students and teachers enabling them to gain skills and understanding to succeed in all things D&T. Not only do they teach, train and run their own workshops they also have their own online e-shop where they sell resources and are the only supplier/ manufacturer of several products for classroom use.

Black Country Atelier (BCA) is a 2012 start-up teacher training institution that provides accredited programs for teachers. Originally the company's focus was ad hoc training of advanced manufacturing skills. They now provide teachers with curriculum support and training that gives them the confidence and ability to deliver the course by themselves to the students. In some instances, they maintain this support for subsequent years.

The schools that BCA work with are varied. In some instances BCA are the facilitators of cross curricular activities because schools may not have the funding for specialist technology teachers (there are a variety of reasons for this). The company currently employs a product designer, computer scientist, filmmaker, architects and a robotics expert. Because the staff are not teachers their role is to ‘team teach’ with the classroom teachers and come up with innovative cross-curricular STEM projects. They work with the teachers to develop school-specific curriculum that will work in their individual circumstances. They primarily work with D&T teachers, with a particular focus on up skilling the teachers with relevant advanced manufacturing skills that enable them to develop relevant and engaging projects.
TechSoft are a UK based manufacturing supplier. They supply advanced manufacturing equipment to schools, offer professional development, training for their machinery, materials and software. The company is based out of their head office in North Wales. They also have six technicians travelling throughout the UK. The creation of the company stemmed from the development of the software package: 2D Design in 1980. The simplistic software is powerful and easy to use. The software supports the output to Roland machinery and various other CAM products. Their unique relationship with Roland DG, amongst others provides a range of output options. The use of the software has grown exponentially, with around 85% of UK schools owning a site license for the software. The beauty of this company is that all of the technicians are former teachers and the owners/founders of the company were also teachers. The business model is tailored for education. The main aim of the business besides selling equipment and their software is to provide schools, UTCs, colleges and training and reliable equipment that is easy to operate.

The Netherlands

The key players for TE in the university system in the Netherlands are Delft University of Technology, Eindhoven University of Technology and Trent University. These universities all have strong programs supporting TE in schools and teachers. These three universities network frequently and also develop and implement programs in tandem. This is important when it comes to lobbying and developing a unified approach to solving TE issues that arise.

In recent years the ministry has developed a different pathway to teacher certification. If you do an education minor in an associated subject, then you can gain an educational license enabling you to teach the subject. Eindhoven and Delft now have students who take this option. These students are favoured in the schooling system. In order to gain your teacher certification students have to finish the bachelor degree before they can become a full time teacher in the schooling system. A number of these graduates then complete the Masters course enabling them to teach upper secondary.

Two years after the introduction of TE in lower secondary, the government decided not to implement TE in upper secondary. About 6-7 years ago this changed as a new subject was developed titled: Nature, Life and Technology. This was developed to be team taught as a combination of different subjects in school; Biology, Chemistry and Design. The curriculum is module based and thematic. It was developed to be a practical course. The modules are developed for this course under supervision by a foundation with the same name as the curriculum. In order for a module to be taught it has to be approved by the foundation. In order for it to be approved it had to be developed in consultation with a teacher, educational researcher and subject specialists from business, or university. Delft and Eindhoven developed modules for this course, which incorporate design process elements. This was reportedly difficult for physics or science teachers to teach. Delft, Eindhoven, Trent then put together a teacher education program to teach this subject with a particular focus on design elements.

A Technasium is a type of school with a heavy emphasis on science and technology, and schools have to apply to have this status. 'Research and development' (the best translation we have) was a new subject that had to be on the timetable. The basis of this subject was projects. The projects had to have a business partner that would give the school a project or a brief to complete. The business/ industry partner would be involved in the development and assessment of this whole project. This model of schooling was not based on research. In principle, this process was good for 'Technology Education' due to the nature of the course. Trent, Eindhoven and Delft joined forces again and developed a course. Not a teaching license this time, just a certificate to teach ‘the design process’. Again, these teachers became leaders in the field. The universities are now trying to develop an agreement with the foundation for them to work together and strengthen the subject.
Professional development is not compulsory in the Netherlands at present. The Ministry is planning a change this and it is expected that it will be mandatory in the next few years. Schools already receive funding each year for teacher re-training. The pedagogy is shifting therefore teaching re-training is essential. These are the only courses at the senior level that are assessed.

Germany

The school visited in Germany was also the main hub for a company called ZDI. ZDI offers training and support to teachers of Technology Education. 70% of all universities are now taking part in ZDI programs and initiatives with over 350,000 students in the state participate in ZDI projects. ZDI is the equivalent of a professional association. The company has expanded exponentially and it now in multiple states supporting the development and implementation of TE in the classroom. In the past this has not been the case in Germany as they had very few schools offering TE as a subject.

Every region has a ZDI coordinator, depending on funding some have multiple. The purpose is for them to train the teachers and lend out the equipment to run the projects. Each region owns a set of equipment. The Federal Employment Agency sponsors $2.5 million euro each year and Ministry of innovation donates $2.5 million euro each year. Each region can apply for a portion of that funding to run projects dependent on what is required in the area. The company provides great networking between schools and meeting for all teachers in the network 2-4 times per year. Equipment for projects is on rotation at all times.

Finland

Finnish speaking teacher training started at the University of Jyvaskyla in 1863. It was the first Finnish speaking teacher education-training institute in the world. Technology Education in Finland is only offered from year 1-9. Therefore the focus of TE or ‘Craft’ as it is called in Finland is quite prominent in the primary years (1-6). However, due to schools changing to a 1-9 structure there tends to be a specialist Craft teacher (high school trained) in most of these institutions. Similarly to Australia, high school TE teachers are specialists in their field. Finnish primary school teachers all have basic training to teach in the workshop (about 25 hours) and this qualifies them to teach Craft at primary level. The University of Jyvaskyla trains primary teachers. The technologies and techniques that are taught to the pre service teachers are traditional and there is little use of new technologies. The university has no Wi-Fi and utilized no advanced manufacturing in their teacher training. The new curriculum has a limited use of the term technology and is still predominately focused on Craft

In Finland there is a professional association. The professional association is a volunteer base and they organise an annual conference called Autumn Days. The association is predominantly specialist TE teachers. To date they haven’t been capable enough to push TE into the LEUMA (Finnish version of STEM). They do have support from the manufacturing industry for supporting TE in schools. They have made some advertising campaigns to support this.

America

"The Hofstra University Centre for STEM Education Research (CSR), founded 1989, establishes new educational visions by promoting and supporting cutting-edge projects related to the improvement of science, technology, engineering and mathematics (STEM) teaching and learning. The Centre leads the development of contemporary online and text-based instructional materials, and convenes research-based professional development programs tailored to the needs of Pre K–16 STEM students and faculty". The aim of the work the centre does is trying to move TE from Craft to one that is more maths and science and aligned with engineering. The centre for STEM research has some great projects that are where students are working on design project and using maths and science. For 15-20 years of the centres
existence they were interested in Design as a pedagogy. They found that most designing in schools is an activity that saps a lot of time and the kids are 'gagateering'. They are using trial and error or Craft. The focus is on the product no the process of learning. There is no intellectual closure on it.

They developed a theory called; Informed design. Before the students start to design they need to inform their knowledge base about the elements that could make their design an effective one. Sometimes there is some directly related maths and sciences. Sometimes is ethics, sometimes it is systems theory. They start with a design activity/ design challenge. They know what it is intended to do. They then complete pre designed practical activities that serve the purpose of developing their knowledge base, relevant to the design project at hand. It narrows the amount of time making it more feasible. Streamline the standards and key ideas, assimilate them then they can approach the project with an informed knowledge base.

Because of the nature of the work the centre does they train teachers to teach the programs associated with their research. They also work alongside these teachers to develop better projects. This centre has strong ties with several schools. Unfortunately not all, however, the projects and programs that they develop are then disseminated into more schools. This is excellent for the teachers as it does help them understand and implement design education. The centre does not do much in the way of CAM although, CAD is utilised in their programs quite extensively.

The California University of Pennsylvania offers an undergraduate teachers degree called Bachelor of Science in Education: Certification in Technology Education. Their technology education program prepares undergraduates for K-12 technology education teaching certification through the Pennsylvania Department of Education (PDE). Their definition of TE is; Technology education includes the study of selected technological systems that explore the solutions of technological problems and their associated social and environmental impacts. The campus is very traditional in set up and tools available. They also have a variety of newer technologies such as milling machines, lasers and 3D printers that they feel is important to teach their undergraduate teachers. Their program appeared to have a good balance of traditional and newer technologies and they placed an importance on both in the classroom.

Engineering is Elementary (EIE) is a unique program developed by a group of the same name in Boston. The Museum of Science, Boston is home to EIE and the nation's first science museum with a comprehensive strategy and infrastructure to foster technological literacy in both science museums and schools across the United States. In 2004 the Museum, led by its president and director Ioannis Miaoulis, launched the National Centre for Technological Literacy to enhance knowledge of STEM for people of all ages and inspire future scientists and engineers.

In order to integrate engineering into schools and museums nationwide, the NCTL strategy involves: 1) advocacy; 2) reform of standards and assessments; 3) creation of K-12 curricula and museum programming; 4) teacher professional development (PD); and 5) enhancing public perceptions of engineering.

EIE is an inquiry-based STEM curriculum that teaches students thinking and reasoning skills needed for success. Built around the engineering design process, EIE teaches students how to solve problems systematically creating skills, optimism, and attitudes important for their futures. Engineering is Elementary supports educators and children with curricula and professional development that develop engineering literacy. Their aim is to increase the number of schools in the U.S. that include engineering at the elementary level.

The program, aimed at elementary schools students, is a hands-on curriculum that requires students to solve problems with scientific and mathematical principals through the design process. There are 20 units of work available for grades 1-5. There are also after school programs for students in years 3-5 and 6-8.
EIE receives the majority of its funding from the National Science Foundation (NSF). Because of this the program is heavily based on research. Each unit of work it developed, tested, evaluated and refined over and over again before it is sold. The units of work can be purchased online and EIE also provides appropriate professional development for each unit so that the teachers feel comfortable delivering the unit in front of a class. This also gives them the confidence to further explore scientific principles that they may not have taught before.

The professional association supporting the teachers and students throughout America is called International Technology and Engineering Educators Association (ITEEA). The ITEEA similar to the D&TA provide a range of professional development and networking opportunities for its members. They have full time employed staff and are also the association responsible for developing the standards for Technological Literacy. The association runs an annual conference in a different state every year. The association has a range of resources that it develops and sells to counties to make implementing TE easier for the teachers. Each state also has active leaders who provide professional development opportunities for the teachers. They have a range of publications and also a journal and newsletter that they send out to all members to keep them informed with any developments, this is generally STEM related.

Technology Education and STEM
In a way the misconception about what TE offers students comes from us making the mistake for too long of staying away from science. Science was thought of as the big enemy. The issue with staying away from science is that it automatically puts you at the low end of the education spectrum. The fear of being too close to science is that you are absorbed, but by now we know what technology education should be about. We have enough research to substantiate this. Therefore affiliating with science would be ideal, STEM is a good model. If we still are not able to function well in the consortium of math and science and if STEM doesn’t work then the thinking should be reconsidered because staying away in isolation has not proven to be effective.
Part 3- Technology Education: A transferrable skill set

During the Fellowship, two manufacturing suppliers, three science/technology museums, a manufacturing plant, three conferences and 40 lectures of personnel from various industries relevant to Technology Education were attended. Throughout the study there were some re-occurring themes that emerged.

1. The skill set provided to students through the TE area of study such as critical and creative problem solving skills are a transferrable skill set.

2. It is important to teach students about newer technologies, such as advanced manufacturing technologies to prepare them to solve the problems of the future.

Over the two days spent at HR Tech Europe (human resources) 16 presentations were attended on Human Resources from a diverse range of business and education institutes. The underlying message taken from the conference was quite simple, and was a concept referenced in many presentations. The HR 'industry' has a model of training that they find most effective for training and developing staff, known as the 70:20:10 approach. This is a methodology that is reminiscent of the philosophy of Technology Education. The HR model refers to the need to have 10% formal learning such as theoretical information; 20% social learning, networking with others in the profession; and 70% experimental learning. They have found this to be far more effective than sending staff to theoretical training courses whereby they might attend these courses for 3 days and return to work with only a very small percentage of the information that they retained. Workforce learning is also best conducted by stimulating; new and challenging experiences, opportunities for practice, rich conversations and networks and spaces for reflection. Big Businesses around the world are aligning with TE methods of teaching and learning. The practical hands-on approach to learning is something that businesses, across multiple industries, use throughout the world.

During the time at the European Manufacturing Strategies Summit 18 presentations were attended. 300 people attended the event from manufacturing companies in Europe including Henkel, Airbus, Alstom, Peugeot Citroen, Bayer material science, L’Oreal, Borg Warner, Philips and Bosch. The conference was also well represented by universities such as Cranfield University and Cambridge.

A panel discussion explored the question: How can Europe avoid losing out to the emerging markets? The majority of the discussion revolved around a skills shortage. This is something that is frequently discussed in Australia as well. There were genuine concerns about the state of the manufacturing industry and that people do not want to see the industry propped up by the government and large loans. Their solution was that it is about creating a level playing field. The biggest concern is that people see the need to go to university and acquire knowledge for the sake of acquiring knowledge rather than focusing on the skills that are actually required to solve problems.

This same theme carried though to the International Manufacturing Technology Show (IMTS). IMTS is the largest manufacturing technology show in the Western Hemisphere. IMTS 2014 drew more than 114,000 industry decision-makers over the six day show. People are drawn to the show to get ideas and find answers to their manufacturing problems and to see new solution demonstrations. As a manufacturer it is a good place to compare technologies from around the world in one place and gain the edge needed to stay competitive in their field. As an educator it is good to see real ‘emerging technologies’ up close and also to gain an understanding of their impact.

A major concern among the key note speakers was building a community of workers to fill their needs now and in the future. This was addressed by the Smartforce Student Summit, which captured the imagination of young people with the truly innovative technologies on display. During IMTS 17,767 students, educators, administrators and parent chaperones made their way through the Smart force Student Summit. The exhibition had more than 50 hands-on exhibits, the Student Summit was able to provide a fun and interactive environment to introduce educators, students and parents to exciting innovations in manufacturing technology and dynamic careers in the manufacturing industry. Some other key points raised by the speakers included; the highest paid jobs in America are in Science and Maths. 3.8 million
jobs were unfilled due to under training and being un-skilled. In order to upskill students need to learn to learn and problem solve. 39% of companies report an inability to hire people with the right skills.

At the European Manufacturing Summit a presentation by Prof. Dr. Detlef Zühlke addressed the issue of 'Industry 4.0'. The presentation was titled: The vision of smart factories. He discussed the vision of the future of manufacturing. Dr Zühlke broke the 4 industrial revolutions down as follows:

1780-1830 - 1st Industrial revolution- power generation and mechanical automation
1900-1930 - 2nd industrial revolution - Industrialisation
2013-... - 4th Industrial revolution- Smart Automation

He also discussed that the market now needs: Shorter production lifecycles, individualised products and International competition

His theory was that in order for Industry 4.0 to be effective it needs: education. The reason for this is because no one quite knows how industry 4.0 will work yet. It is going to need innovative engineers and designers, along with computers coders to generate a solution to this theory.

Mike James CTO of ATS international spoke about the impact on manufacturing of the ‘Internet of Things’ and the 4th industrial revolution. He stated that the future of manufacturing is that machines will talk to each other and they will talk to the product. They will be intuitive. The product will start as a chip. It will have all of the information required to have the product made specifically to customer orders. This chip will talk to the machines. This is a substantial change to how the products are made today. The machines are programmed with our (human) intelligence. It has to be modular and flexible. However, 4.0 is only possible with knowledge and skills. It is not just IT and it is not just the Internet. It also revolves around manufacturing techniques and materials. The 20-year prediction is that this will be the norm across the manufacturing industry but it requires this generation and the next to solve the problem of how.

Reference List
Conclusions

The original focus of this study began with investigating a dichotomy of Technology Education of the future. The finished product highlights the importance of Technology Education holistically. In conclusion:

- Although the format and the approach toward Technology Education in the countries studied appear in different forms, for the most part the curriculum in those countries present more common features than uncommon. However, there are few contradictions among the elements.
- The universal goal of Technology Education is Technological Literacy, meaning; students are to gain an understanding of the role of science and technology in a changing world, they are to become ethical and responsible designers and consumers, they are to be technologically literate and to develop skills such as planning, making, evaluating, critical and creative problem solving and to be entrepreneurial. All of these elements can be seen in the TE curriculum throughout the states and territories of Australia and in the Australian Curriculum: Technologies. In terms of content and concepts the ACARA and state syllabuses resulting from it are futuristic, relevant and appropriate.
- From looking at the curriculum in each of these countries the Australian Curriculum: Technologies is the only curriculum that isolates ‘Digital Technologies’ from ‘Design and Technology’. It is also the only known example that mandates the study of digital technologies at any level. The study of ‘digital technologies’ (or equivalent) is elective in the high school setting.
- England, USA, Finland and the Netherlands all have a national Technology Education document in some form (standards, achievements standards, national curriculum, framework). It is timely and necessary for Australia to have such a document.
- The use of advanced manufacturing is still fundamentally optional in all curricula studied. The main reason for this is equity. Whilst advanced manufacturing is often referred to in each of the curricula, the outcome or achievement can be fulfilled without having to understand how to use the technology. In Finland there was no evidence of advanced manufacturing technology. Most schools visited did not have computer access for the Technology Education area of study. From what was witnessed it can be reported that the UK and USA are on par with the use of advanced manufacturing in NSW Australia. An informed conclusion cannot be drawn about other states in Australia.
- The use of advanced manufacturing in the classroom depends on two fundamental elements: 1) Funding 2) teacher understanding and willingness to incorporate the technology. Students are not the issue. If they are given the opportunity to use a new technology they welcome it with enthusiasm. They are inquisitive and generally, if the technology makes their life easier they are compelled to want to know how to use it. However, this depends on the school/county/district/government having the available resources to purchase the software and machinery. For the most part software such as Creo, AutoCad/Inventor and Google Sketchup are all provided free to schools, teachers and students. Therefore appropriate software is not the limitation. The machinery is. Machinery is slowly becoming less of a limitation with the cost of advanced manufacturing machinery dropping, becoming more affordable for schools to purchase. This was evident in UK, USA and Germany and is also evident in Australia.
- The biggest limitation to the use of advanced manufacturing in the Technology Education classroom is teachers. The willingness to accept the change required to utilise advanced manufacturing in the classroom comes down to the educator. There were many times during the study schools had 3D printers, lasers and milling machines not being utilised. The common response as to why it was not used was ‘they don’t know how to use it’ or the school just bought it and provided no professional development. This trip highlighted that these CAD skills and the CAM machinery is not a fad. It is the future. There is still a need for students to understand and know how to use traditional technologies, however, the world is changing and students need the skills to be prepared for the future. There are some major points of disparity between what is happening in Australia and what is happening in other countries in terms of teacher support of Technology Education.
- In the countries visited teacher support becomes the responsibility of Professional Associations or similar corporations. The UK has the Design and Technology Teachers Association, the USA have the International Technology Engineering Educators Association, Germany have ZDI, Finland have
the TAO organisation, Netherlands have Trent University, Eindhoven University of Technology and Delft University of Technology that band together and offer support courses. In each of the examples provided the associations provide consistent, accredited, ongoing support for their teachers. In the examples provided the associations employ staff this enables them to deliver and source relevant, emerging information and skills as professional development opportunities. These associations and ‘teacher support structures’ are consulted with when it comes to the development and proposed changes to curriculum. They are the vital link between politicians, education departments and teachers. In Australia we have DATTA Australia. Each of the states in Australia has their own association. However, most do not employ staff and are volunteer only providing a very limited amount of professional development due to the time restraints that full time teachers have. There are only few universities in Australia now offering undergraduate Technology Education Teacher training. As a result they do not offer ongoing teacher support in the way of accredited courses. The irony in this matter is that from 2016 it is compulsory for all teachers in Australia to log ongoing professional development throughout their career. The reality is that there are very few providers providing relevant training for the needs of the teachers.

• The focus of study was to determine if the dichotomy in Technology Education of the future is a problem. Based on the research conducted the researcher is of the opinion that the dichotomy is not a problem. The problem is that in order for students to have the skills to solve problems of their generation there needs be more of a focus on advanced manufacturing and control systems in our current Technology Education curricula and teacher training. There is still a need for traditional technologies and hand skills to compliment the new generation of advanced manufacturing and techniques. It is important that there is an appropriate balance of both.

Recommendations

The following is recommended for change and implementation in Australia:

• Teachers need more support and appropriate professional development in Technology Education
• The state and national Professional Associations for Technology Education need more support from the government, curriculum authorities and appropriate bodies to ensure they can provide appropriate, accredited professional development for Technology Education teachers to support and continually develop their understanding of emerging advanced manufacturing technologies.
• The identity of Technology Education in Australia needs support and wider recognition for its contribution to the education of students.
• There needs to be more of a focus on advanced manufacturing and control systems in the Technology Education curricula and in teacher training in order to better prepare students for the future.

Dissemination

Twitter: @aleshableakley
Presentation at Technology Education Conference, Sydney, November 2014
Presentation at DATTA Australia meeting, November 2014
Presentation at liate meeting, Term 1 (February 14th) 2015

The forwarding of the summary findings to;
• NSW Department of Education and Communities – Minister and State Office
• NSW Catholic Education Office
• NSW Independent Schools Association
• Federal Minister for Education
• Board of Studies Teaching and Educational Standards (BOSTES)
• Inspector Technology Education BOSTES
• ACARA
• Australian Academy of Science
• DATTA Australia
• Institute Industrial Arts- include articles in upcoming journals
• Other state TE associations
• All schools and institutions visited
• Australian Manufacturing Technology Institute Limited