2019

A Critical Perspective on Technology Education in Australia

Kurt W Seemann

報　告

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第 13 回技術教育創造の世界「発明・工夫コンテスト」の報告

島田 和典*
Kazunori SHIMADA

1. はじめに

2018 年度で第 13 回となりました，技術教育創造の世界「発明・工夫コンテスト」は，皆様からたくさんのご応募を頂き無事終了しました。学会誌の紙面をお借りし，コンテストの報告とお礼並びに学会長賞を受賞した方の「受賞の喜び」を掲載させて頂きます。

本コンテストは，教員養成系大学に在籍する学部生，大学院生，および卒業・修了して 2 年以内の社会人が，個人またはグループで製作した作品(社会人の場合，在学中に製作したもの)について，5 つの部門に分かれて競うものです(教員養成系大学以外でも，本コンテストの趣旨に賛同する方は，応募可能)。2018 年度は，12 月 20 日まで募集を行い，表 1 のように 5 部門合計で 17 大学・42 件の応募がありました(2017 年度は 15 大学，39 件，2016 年度は 15 大学，50 件)。なお，応募のうち，学部生 29 件，大学院生 11 件，卒業・修了(2 年以内)2 件，個人応募 31 件，グループ応募 11 件でした。

2. 審査および審査結果

審査は，本学会の理事が Web に掲載された説明資料およびリンク資料を閲覧し，作品毎に以下の採点基準に従い，10 点満点で採点をしました。

①製作の動機または目的が適切である。
②作品の利用方法が適切である。
③作品自体やその製作過程に工夫がみられる。
④「説明資料」およびリンク資料に記載された文章，写真，図が明確である。

審査の結果，2018 年度は学会長賞 3 作品，特別賞 7 作品，奨励賞 11 作品の計 21 作品を選出致しました。以下の Web サイトには，審査結果と共に，応募された作品を掲載しております。各大学で参考にして頂き，2019 年度の応募に向け参考にして頂ければと思います。

発明・工夫コンテスト Web サイト
`http://www.jste.jp/hatumei-c/2018`

3. おわりに

本コンテストは，教師を目指す学部生，大学院生の教材開発力や創造性の高揚，教師力の向上を目指しています。今回のコンテスト結果につきまして，受賞した学生の所属大学での受賞報告及び新聞報道等において数多く広報頂いております。このようにコンテストやその成果が，広くアナウンスされることは，事務局としても嬉しいことです。

2019 年度も同様に開催を予定しております。多くの大学生，大学院生からの応募をお待ちしておりますので，よろしくお願い致します。

表 1　コンテストへの応募状況

部門名	参加大学名	出品数
発明工夫	帝京大学	1
	北海道教育大学	1
	釧路公立大学	1
	鳴門教育大学	1
	静岡大学	2
	福山大学	1
	日本大学	1
	大阪電気通信大学	1
教材開発	静岡大学	10
	愛知教育大学	1
	宮城教育大学	1
	福山大学	1
	信州大学	3
	大阪電気通信大学	3
	山口大学	1
	岐阜大学	1
	広島大学	1
	三重大学	1
プログラム	静岡大学	1
	大阪電気通信大学	1
スキルアップ	愛知教育大学	2
	静岡大学	2
	東京学芸大学	1
	山口大学	1
その他	岐阜大学	1
	九州産業大学	1
参加大学数合計(17)	合計	42

* 技術教育創造の世界「発明・工夫コンテスト」事務局
東京学芸大学 (正会員 A)

おじいちゃんトイレ終わりましたか
－トイレでの高齢者の転倒を防ぐ声かけシステム－

帝京大学理工学部情報電子工学科　蓮田研究室　飯田 雅裕・劉 嘉

1. はじめに

少子高齢化により，介護者への負担も急増している。排便時の待機や見守りに多くの時間と労力が必要であり，排便後に立ち上がろうとして，転倒骨折する事例が数多く報告されている。対策として，声かけが極めて有効であり，立ち上がる前に「〇〇さん！終わりましたか」，「座っていてください」と知らせ，介護者が駆け付けるまでの時間を稼ぐことが必要である。

そこで，図 1 に示したように排便終了時の動作であるトイレットペーパーの引き出し時に，音声で注意を促すとともに介護者のスマートフォンに通知を行うシステムを考案した。トイレットペーパーの引き出しを検知するために，ホルダーの蓋の裏側に加速度センサーを設置し，同時に介護者のスマートフォンへ通知する。

2. 開発した排便時の声掛けシステムとその工夫点

2.1　工夫点 1　鍵加速度センサーを用いて引き出しを検知

ペーパーホルダーの裏側に加速度センサーを設置することで，トイレットペーパーのわずかな引き出しを検知可能とした(図 2 参照)。

2.2　工夫点 2　利用者に対して音声で注意を促す

利用者がトイレットペーパーを引き出す際に，スピーカーで注意を促し，立ち上がらないようにした(図 2 参照)。

2.3　工夫点 3　介護者のスマートフォンへ通知を送信

今回開発したシステムでは，介護者がトイレの前での待機負担を軽減するために，トイレットペーパーの引き出しを介護者のスマートフォンにも通知する機能を付加した。マイコンをインターネットに接続することで，スマートフォンに対して通知する(図 3 参照)。

3. おわりに

この度，日本産業技術教育学会主催第 13 回発明工夫作品コンテストにおいて学会長賞を頂き，身に余る光栄に感謝申し上げます。反響も大きく，新聞各社から取材を頂きました。

今回開発したシステムは，被介護者・介護者の両者に良い効果をもたらすと考えられる。今後は独自アプリを開発し，利用者との通話ができるようにするなど，更に利便性を向上させたい。

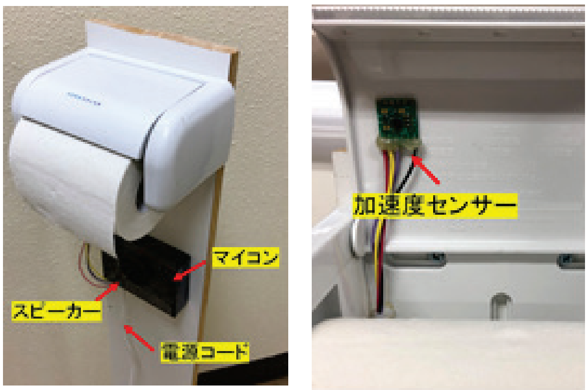

図 1　トイレットペーパーの引き出し検出と声かけシステム

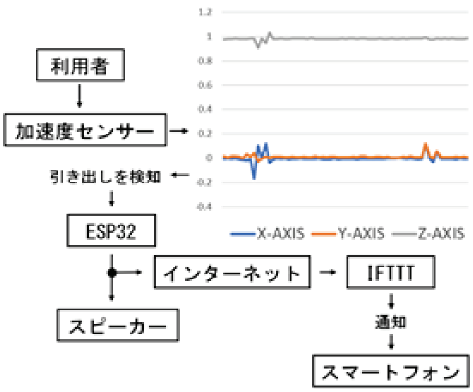

図 2　開発したシステムのブロック線図

図 3　スマートフォンへの通知

1.5V 駆動 昇圧型直流電流源

静岡大学教育学部　嶋崇 志輔

1. はじめに

この度は，第 13 回技術教育創造の世界(大学生版)発明・工夫コンテストにて教材開発部門学会長賞という栄えある賞を授与頂き，誠に光栄に存じます。以下に，作品の概要について紹介させていただきます。

2. 背景及び目的

LED は製造段階で生じる公差により，個体ごとに $V_F - I_F$特性が異なっていることから，絶対最大定格内で安全に駆動するには，電圧ではなく電流による制御が必須になります。そこで，中学校技術科において LED を用いた回路設計を簡易的に行うことを目的とし，単 3 乾電池 1 本(公称電圧 1.5V)で駆動する昇圧型直流電流源の製作を行いました。製作にあたり，1. 昇圧の実感を伴った理解に繋げるため 1.5V で駆動すること，2. 設計の幅を確保するため LED を複数個駆動できること，3. 回路が簡単であることの 3 点に留意しました。

3. 作品の概要

3.1 動作概要

作品の回路図を図 1 に示します。昇圧回路には，ブロッキング発振回路の一種であるジュールシーフ回路を，単なる発振器としてではなく技術教育向けに研究を進めて採用しました。以下に回路の動作の流れを示します。まず，ジュールシーフ回路の発振昇圧動作を用いて 1.5V の直流電圧をパルス状の高電圧に変換します。続いて，パルス状の高電圧をショットキーバリアダイオードとコンデンサを用いて平滑化し，ツェナーダイオードにより上限を 20V に設定します。ジュールシーフ回路は，無負荷状態では数十 V を超える電圧を出力しますが，ツェナーダイオードを用いることで，簡易的に作業者の安全確保及び電子部品の保護を行うことが可能になりました。こうして得られた直流電圧を可変三端子レギュレータの駆動電圧として使用します。可変三端子レギュレータは，in，out，adj の 3 つの端子を持ち，out－adj 間は参照電圧 1.25V に保たれています。通常はこの参照電圧を利用した任意の電圧生成に用いられることが多いですが，今回は，adj 端子を負荷に接続することにより電流生成素子として機能させています。

3.2 LED の数と定電流領域

out－adj 間の抵抗を変化させ，10，7，5，3mA を生成し，高輝度赤色 LED (OptoSupply，OS5RPM5111A-TU)を直列接続で増加させたときの電流値を調べました。その結果を図 2 に示します。図 2 に示す結果から，LED を直列接続で増加させても電流値が一定となり，直流電流源として利用できることが確認できました。個数や発光色を自由に変えることができるため，目的に合わせて創意・工夫できる設計学習が簡易的に行えるようになると期待しています。

4. おわりに

本作品を製作及び研究するにあたり，有益かつ丁寧なご助言をいただきました静岡大学改正清広准教授に改めて深謝いたします。

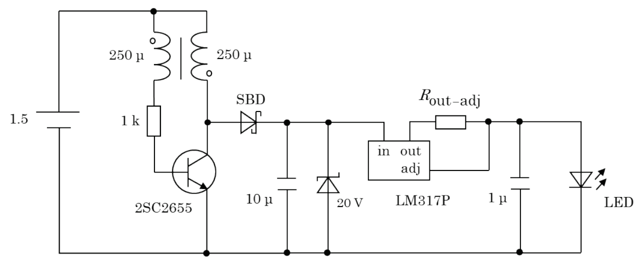

図 1　昇圧型直流電流源回路図

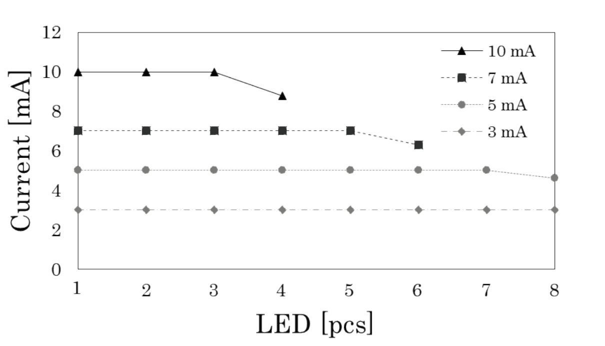

図 2　電流源の定電流領域

木電池を活用した電源装置

静岡大学教育学部　鄭研究室　望月 宏信

1. はじめに

この度は第13回技術教育創造の世界，発明工夫コンテスト教材開発部門におきまして，学会長賞という栄誉ある賞を授与していただき，大変うれしく思います。この賞をいただいたことに対する感謝を申し上げるとともに，作品の概要について本誌面をお借りして紹介させていただきます。

2. 木電池を活用した電源装置

2.1 木電池の概要

図 1 に木電池の概要を示す。比重が約 0.3 のスギ材は経長比約 100 倍のストローのような構造をもつ。したがって，表面張力によって毛細管現象が生じ，体積の 7 割以上の水分を保有することが可能である。また，圧縮・回復の過程で生じる吸引力から食塩を簡単に内部に挿入可能であり，乾燥状態にすることで半永久的な保存に加え，水に浸けることで長時間の非常電池として活用することが可能である。

2.2 木電池装置の製作

木電池装置は 30×30×30(mm)の大きさの木電池 4 個を図 2 に示すよう直列および並列に接続することで，端子電圧及び電流値の上昇を行うことが可能であり，適切な接触方法により，LED を長時間点灯させることも可能となる。

2.3 情報教材としてのモールス信号送信機

図 3 は本教材の概要を示す。製作した電池装置は電気二重層キャパシタに接続することで，二次電池および安定した電源として活用できる。これをさらにジュールシーフ回路に接続し昇圧させることよって 700mV の電圧で高輝度 LED の点灯および圧電ブザーの動作が可能となった。この一連の回路にスイッチを加えることで，任意のタイミングで光や音を送信する信号として扱う，情報教材としてのモールス信号送信機を開発した。本教材の特徴としては，図 4 に示すようにラグ端子に真鍮釘を用いることで，回路図を見たままにはんだ付けが可能である点や，電波で送信する信号とは異なり受信機を用いずに情報の受発信が体験できる点などがあげられる。

3. おわりに

この度，発明工夫コンテストに出展するにあたり，有益なご助言をしてくださいました，鄭基浩准教授に感謝申し上げます。

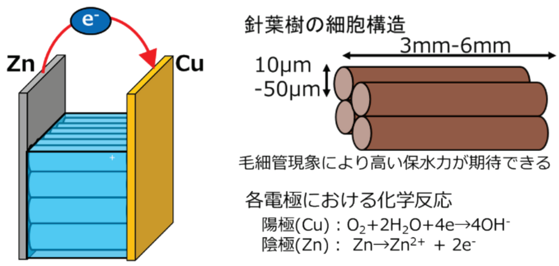

図 1　木電池の概要

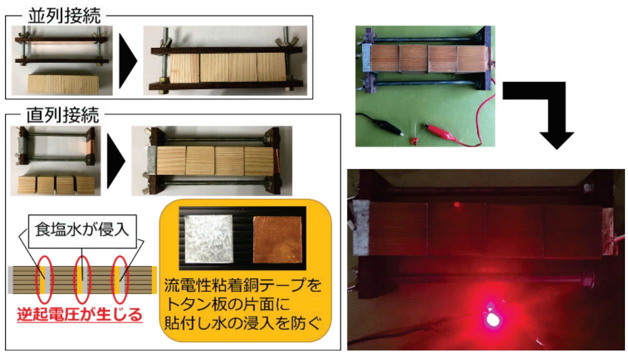

図 2　電池装置の製作・使用風景

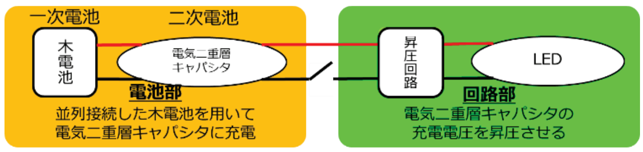

図 3　電源装置を活用したモールス信号送信機の概要

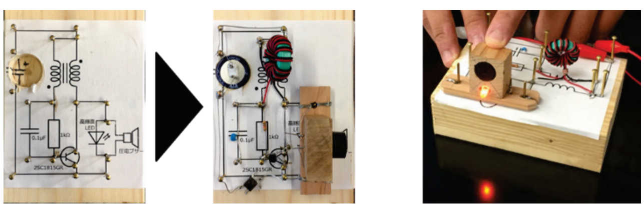

図 4　モールス信号送信機の製作・使用風景

A Critical Perspective on Technology Education in Australia †

P John WILLIAMS* David ELLIS* Jeremy PAGRAM*
Denise MACGREGOR* Kurt SEEMAN* Shinichi FUJITA**

Technical education has a long history in Australia, and the curriculum area is now currently known as Technologies Education. Two significant milestones in that history include its declaration as a compulsory learning area in 1987, and its inclusion in the national curriculum in 2014. While this indicates a strong curriculum position for the learning area, there remain a number threats to its continuity. The threats include a shortage of teachers, student and community attitudes, STEM and the costs associated with providing a contemporary technology program.

Keywords: Design and technology, Technology education, Technology curriculum, Australia

1. History of technological education in Australia

The introduction of technology education, or more appropriate for the time, technical/vocational education, into Australia was an inevitable consequence of the young colony as it developed during the 1800's. A problem of these early times was the large number of deprived and neglected children roaming the streets. "These children, more than likely, only had a mother, usually a prostitute or at the very least a drunk, and fathers, if known, being convicts" (Dickey, 1968, p.139). The sight of these children running rampant in the back streets of Sydney proved to be of great concern to the middle class sector of the community, who saw this to be a blemish on the society of the time. As a result pressure was brought to bear on the government of the time to remedy the situation (Murray-Smith, 1966, p.72).

The concern of the community was that these children because of such a poor start to life, would become the next generation of petty criminals, missing out on the opportunity to become useful members of the community. To remedy the problem, it was proposed that industrial schools or orphanages be established. It was intended that in these institutions the children would be trained in trade skills, along with moral and some limited general education.

The government visualised the early institutions as training centres that would provide children with technical skills in a trade that was in demand at that time. These skills would provide the children with an avenue to take an honourable position in society by providing them with means of earning an honest income rather taking up those of their past. Another benefit of these training centres was to provide the limited workforce with skilled artisans, labourers, workmen and domestic help (Barcan, 1965, p.26).

These schools for a range of reasons never quite fulfilled what was envisaged for them by those who proposed their introduction, but nevertheless they represented the origins of technology education (Murray-Smith, 1966, p.37). It is interesting to consider that it was a shortage of skilled tradespeople that was in part to provide the first form of technology education for the country.

The first real efforts to introduce technology education into the curriculum occurred towards the end of the 19thC. The 1880's saw the country in the depths of a depression, the recovery from which, after almost a decade, saw the need for "....restructuring

* Refer to "6.Author note".
** International Relationship Committee, JSTE
† The report is written by Design and Technology Teachers Association, Australia, by invitation of the International Relationship Committee. (国際関係委員会の事業としてオーストラリア技術教育教員学会に執筆依頼した報告書 No.6 である。)

the economy in a way that focused attention on the growing need for a higher level of technical and commercial skills in the workforce" (Laird, 1982, p.74).

Murray-Smith (1966, p.418), although referring to technical education in general, made a very apt statement concerning the influence of the Depression upon the public's perception of the role of technology education: "... an early expression of the viewpoint that in slack times it was part of the duty of technical education to take over some of the responsibility of the individual employer".

This statement, though referring to the period of the late eighteenth Century, describes what was to become a pattern in technology education in Australia, that in times of depressed economic activity, new levels of awareness of the role of technical education are the result.

As a result of overseas experiences by Australian educators, particularly in Britain, technical schools were developed in Australia. Primary students of the time were directed to the schools most appropriate to their perceived academic aptitudes, students who were identified as being more academic were directed to the more traditional classic curriculum. Students who were less academically capable were directed to gender oriented technical schools. The curriculum of these schools included subjects that were drawn from the common trades of the time, they included studies in woodwork, metalwork, trade drawing (in the technical schools) and cooking, hygiene and sewing (in the domestic schools). Through the second decade of this century the vocational or technical subjects became the dominant part of the curriculum of these schools.

These schools never became popular, partly because "... employers generally attach little or no value to the vocational school training of children prior to their entry into the vocation itself....the employer asks for intelligence rather than skill in the choice of his beginners" (Murray-Smith, 1965, p.874).

Technical education was to receive little attention during the 30's and 40's, because of the Great Depression and World War II. It was again, as in the late 1890's, that a period of economic downturn was to focus attention on the role of education. Unlike the earlier situation the nation was involved in World War II very quickly after the end of the Depression. During this time there was rapid economic growth in the industrial sector providing many employment opportunities. The country was in a period of economic boom so there was not the same focus of attention on the technology component of the curriculum as in the past.

There developed a recognition of the status of technical subjects. The Wyndham Report stated this discontent very strongly:

> I feel that the highly undesirable and unfortunate, and clearly undeserved, stigma associated with the Domestic Science and Junior Technical courses at present to be found among teachers within the schools and the community in this State........will be partially removed at least by encouraging the participation of all secondary students through numerous electives to partake of some such subjects voluntarily and by encouragement - all as a part of his or her own educational diet as it were. The dignity of the wide diversity and levels of vocation could be dealt with (Wyndham, 1957, p.155).

As a result, some technical subjects became compulsory, and the range of technical subjects offered was broadened, but this did not happen until the 1970's. Some of these subjects were not prescriptive in the structure or the content of the course. The teacher was given control over the development of the curriculum, the expectation was on the teacher to structure the curriculum to the local situation and the interests of staff and students. Teachers, however were not used to such freedom, and these curriculum were later replaced with a very prescriptive curriculum.

In the 1980's, Technology became accepted as one of eight curriculum learning areas in all Australian schools. In 1987, the Australian Education Council (AEC) began a series of initiatives that led to the publication in 1994 of nationally agreed curriculum statements and profiles related to eight learning areas, one of which is technology. In 1990 the K-12 Technology Curriculum Map (Australian Education

Council) revealed a shift in emphasis in many schools toward gender equality, flexible outcomes and a variety of teaching and assessment strategies.

The declaration of technology as a learning area had profound implications. Prior to this, all subject areas in secondary schooling from which technology education developed were located within the elective areas of the curriculum. The implication was that these subjects provided learning experiences relevant only for specific groups of students with particular interests or career destinations in mind. Indeed, some of these subjects were regarded by students and the community as relevant only to a particular gender. Secondly, in the case of primary education, technology had not generally been part of school programs, and primary teachers had little experience to draw on to develop programs. The challenge for technology education was to determine the learning experiences that are essential for all students, and are unique to technology education or best undertaken within the area.

The most significant rationales for the development of technology as a discrete learning area were related to the technological nature of society and equity of opportunity for students. Australian culture was rapidly becoming highly technological, and all students needed to have the opportunities to develop, experience and critique a range of technologies as part of their core education. This rationale aligned with concerns for gender equity in technology education, with more flexible, open ended and collaborative approaches to delivery, and with a range of key competencies for all students.

A Statement on Technology for Australian Schools (Curriculum Corporation, 1994) set out what was regarded as the technology learning area. This included the place of technology in society, the need for all students to experience technology education and the form in which it should appear in the school curriculum. It outlined four strands for learning in technology education: Designing, Making and Appraising; Information; Materials; and Systems. These were regarded as interdependent and were intended to be developed sequentially through stages or levels in the compulsory years of schooling.

The technology classroom activities of today have developed out of the technical traditions. At the primary school level technology education practices tend to have developed out of art and craft and science. Technology and Science (and increasingly, STEM) tend to be bracketed together for primary education. At the secondary school level, technology education has tended to develop out of vocational studies such as Home Economics, Industrial Arts, Agriculture, and Business Education as well as other technical studies such as Computing, Information Technology, Media and Control Technology.

Probably the most significant aspect of the change to technology education is the concept that as a learning area it contributes to all students' general education and therefore should be studied by all students in the compulsory years of schooling.

The breadth and dynamic nature of technology itself is necessarily reflected in this technology education. This is a positive educational attribute resulting in a healthy diversity of approaches across Australia to the teaching and study of technology. At the same time, this diversity provides challenges related to national curriculum development and teacher support.

The public education system in Australia is managed individually by five state and two territory governments. The federal government provides some funding to all schools to support specific priorities and strategies, but the majority of school funding comes from state and territory governments. Up until recently, the school curriculum was also developed at the state level, but in 20xx, a new national Australian Curriculum was implemented. Technologies is one of the core curriculum areas, which incorporates Digital Technologies and Design Technologies.

Technology Education is well established as a core learning area in Australia, although there are still aspects for development. For example in terms of professional development, primary teachers' are still becoming familiar with the area, and in secondary schools Technology Education is still evolving from a technical tradition. In addition, there is still significant diversity of practice in schools because states and territories are educationally independent.

While this can be seen as a healthy diversity of approaches to the teaching and study of technology, diversity provides challenges related to national curriculum implementation and teacher support. As schools work toward the development of the national Australian Curriculum, the current level of diversity will decrease.

2. The National Curriculum

Technology education as a learning area has been discussed in the previous section of this Chapter, with the understanding of what value it can have on developing the capacity of the learner. In Australia, the technology education curriculum is diverse. Not only is this diversity a result of the various State and Territories that have been responsible for the curriculum design and implementation prior to the publication of the National Curriculum: Technologies in 2014, but the 'packaging' of technology education curricula into subjects that focus specifically on either design processes (i.e. Product Design and Technology in Victoria) or materials (Industrial Technology-timber in New South Wales). The Australian Curriculum: Technologies was written for students from Foundation (Kindergarten) to Year 10, but implementation after Year 8 is at the discretion of the relevant State or Territory Authority (ACARA, 2013). Any diversity of technology education curriculum in Australia is a result of the difference between those states that have implemented the Australian Curriculum as it was written, compared to other states who have 'repackaged' it, to incorporate it into their own curriculum. In this section of the chapter, it is this 'packaging' of the Australian Curriculum: Technologies as 'official knowledge' (Bernstein, 2000) that is of interest, as stakeholders have influenced 'what' students should learn and 'what' should they be able to do, packaging and re-packaging it based on identified needs. But whose needs are they?

One element of the National Curriculum: Technologies was a distinction between the 'types of thinking' that occur in design and technological activities. As a result, two distinct, and mandatory subjects resulted, with Design and Technologies emphasising 'design thinking' as students engage in a design and 'making' processes, and Digital Technologies emphasising 'computational thinking' with the use of digital systems to create solutions. Even though it has been acknowledged that both of these types of thinking are "utilised in each subject" (ACARA, 2012, p.8), the curriculum designers deemed it necessary to have two distinct subjects.

As an example, New South Wales (the most populous state in Australia) repackaged the National Curriculum: Technologies (NESA, 2017) content into an approach to suit the state. Digital Technologies was not separated from Design and Technologies and was integrated into a single Technologies curriculum. With this example in mind, the packaging of curriculum is not necessarily the reshaping of the same 'old' content into new paradigms, new knowledge is needed. This is particularly true for curriculum areas such as technology education, where content is often linked to current technology and processes, but it isn't just new knowledge accompanying new technology that has shaped the National Curriculum: Technologies, there is much more of a broad-minded focus on this national approach to technology education.

Twenty years in the making (MYCEETA, 1998), the development of the National Curriculum in Australia has been influenced by, and built upon the socio-political education goals published in the 2008 'Melbourne Declaration' (ACARA, 2010) that not only develop the individual's own capacity as a learner, but also to develop a set of values and attitudes as "active and informed citizens" (MYCEETA, 2008, p.8) that contribute to society. An example of this is found in the evolution of rationales found in technology education curriculum where there is evidence in shift in the development of a student. Previous curriculum has emphasised the economic value that technology can make to development the capacity of the individual to take "his/her place in society" (SSB, 1985, p.3), to a contribution that is beyond the economic domain. An example of this is the current rationale for Design and Technologies from the National Curriculum: Technologies that envisages students to play a role in "enriching and transforming societies and our natural, managed and constructed environments" (ACARA, 2019), where it is envisaged that students are empowered to transform societal and environmental domains as well.

What has been a strength of past Technologies curricula developed by the various States and Territories has been the explicit encouragement of experiential learning pedagogies (Kolb, 1984), and constructivist epistemologies (Dewey, 1997; Piaget, 1977; Pinch & Bijker, 1994) to engage students in the development of skills and knowledge. The new national curriculum continues to encourage these approaches, ensuring student experience and understandings have "real-world relevance" (Lombardi, 2007). It seems that the new National Curriculum: Technologies, has broadened this trend to develop values and address real world "pressures" (ACARA, 2012), with a focus on the development of "thinking skills", and values as well as the expected practical skills to contribute to "sustainable patterns of living" (ACARA, 2014).

This shift in intention for the Technologies curriculum is appropriate, not only to develop students' capacity to contribute towards a 'greater good', but given the ubiquitous presence of technology in today's world, it is essential to recognise the role of technology education curriculum to enable "technologies knowledge, understanding and skills to engage purposefully in the process of creating preferred futures" (ACARA, 2012, p.7) to flourish.

To determine whether this 'shift' is a perception or a reality, this section of the Chapter will provide a brief background of the National Curriculum: Technologies Foundation to 10 (F-10), then critique using specific examples to demonstrate whether the curriculum incorporates an explicit focus on identified social, environmental and economic pressures. As the implementation of the National Curriculum is the responsibility of States and Territories, rather than national authorities, this section will also discuss any relevant State or Territory curriculum that differs from the national curriculum. We begin with a brief background of the National Curriculum: Technologies.

Prior to the implementation of the National Curriculum: Technologies, the responsibility for the development and maintenance of curriculum was undertaken individually by the eight States and Territories of Australia. Even though the country had previously performed well across international benchmarking data in terms of quality, political agendas such as ensuring equity throughout the diverse regions, the socio-economics of the country (Atweh & Singh, 2011), and a greater consistency in 'what' young people should be taught to equip them for a "changing and increasingly globalised world" (ACARA, 2010) motivated the national curriculum agenda. To determine 'what' knowledge is essential or valued in curriculum renewal development or renewal is often contested, as knowledge is selected and organised (Atweh & Singh, 2011; Singh, 2008). 'What' and 'how' knowledge is produced and organised is done so in a way that is representative of that culture, in a response to the requirements to deal with "contemporary cultural, economic and technological change" (Bernstein, 2000, p.66; Moore, 2007). However, Bernstein (2000) reminds us of the 'contested' nature of curriculum development, where 'official knowledge' is the output of curriculum development processes, incorporating the 'bias' and 'focus' from different stakeholders and groups (p.65).

It is from this perspective that we view the formal National Curriculum: Technologies document as an output of the discussions in the curriculum shaping and development. This output, is the National Curriculum: Technologies document that directs the official knowledge to be taught from Foundation to Year 10 (F-10), though the expectation is that all Australian students will at least study Technologies from Foundation to Year 8.

It is not the intention of this section to elaborate on the development process, nor to recount the contestation and negotiation that occurred during the curriculum development, but to merely highlight the shift towards looking outwards to address the three pillars of social, environmental and economic pressures in the 'official knowledge'. This prescribed knowledge is a result of a curriculum consultation and development process, and influenced by technologies literature and political documents based on socio-political educational goals (MYCEETA, 2008), and identified research priorities (Australian Government, 2015). We will begin with the critique of the National Curriculum: Technologies Achievement Standards, supported by the content using the concept of 'outward-looking' as a form of neo-liberalism (Botella-Rodriguea, 2018) and environmentalism (Kuzich, Taylor, & Taylor, 2015; Parker, Fournier, & Reedy, 2007) to frame the discussion.

Explicitly stated in rationale, and Achievement Standards (ACARA, 2018), there is a visible relationship between the activities undertaken in design processes, and the desire to meeting social, economic and environmental needs in both the Design and Technologies, and Digital Technologies subjects in F-10. Obvious neoliberal concepts relate to identifiable learning outcomes, or evidence of capacity development to address the research priorities of the nation (Australian Government, 2015) in an attempt to encourage 'free market' opportunities, or to develop a capacity for creativity and "the entrepreneurial spirit" (Thorsen, 2010). As a result, any references to meeting needs of users, developing solutions, or being innovative or enterprising will be referred to as evidence of neo-liberalism. In addition to this, there are equal (and not necessarily competing) values placed on environmental concepts, displacing an anthropocentric focus (Gilbert, 1998; Knappett & Malafouris, 2008) of design criteria. As a result. Any reference to the concepts of sustainability and appropriate technology will be referred to as evidence of environmentalism.

Evident in the National Curriculum: Technologies 'Sequence of Achievement' Foundation to Year 10 (F-10), is a clear scaffolding of the content and achievement expectations for Technologies students as they progress in their technology education, with an increasing focus on the external influences and the complexities that surround this influence. As an example, in the Design and Technologies subject, Foundation to Year 2 (F-2) students (aged between 4 and 6 years) experience the processes of design activities with guidance. Throughout this design journey, they are made aware of the concept of 'needs' and the concept of an 'environment'. From an environmentalism perspective, this is pleasing as students are required to describe the impact of design solutions, not only on the user, but also on the environment. Concurrently, students in this age range are also undertaking a study in the other Technologies subject, Digital Technologies. Similar to Design and Technologies, students undergo the experience of designing solutions to "simple problems" (ACARA, 2015, p.3) with a focus on data and information. What may be confusing to students of this age is an alternate concept of an 'environment', where economic cybersecurity, and social and individual safety concerns are addressed. The confusion may arise from the concept of safe 'online environment' where virtual communities exist and how safety can be compromised.

For Years 3-4, at approximately 7 to 9 years of age, an outward-looking focus is scaffolded, along with cognitive expectations in design processes. Design and Technologies students undertake contextual design tasks aligned with the Australian research priorities such as in the area of Food (Australian Government, 2015), being more cognate of the catering to, and inclusion of external influences, such as the "needs of communities and their environment" (ACARA, 2015, p.2). In the Digital Technologies subject, students use "algorithms that involve decision making" (ACARA, 2015, p.3), designing digital solutions from defined problems.

At the end of their Primary Education, technology education students are expected to take more responsibility in terms of project management, and decision making to plan for the development of solutions. In the Digital Technologies subject, there in an expectation for an increased understanding of abstract concepts such as networks, whole numbers and different representations of data. Whilst this is important from a social or economic perspective, approaches to solution development only peers through a human-centric lens, as students use algorithms to develop design solutions with an empathetic approach towards the experience of the user. There are references to sustainability, but this is only from a social and user perspective, not explicitly an environmental one. To reduce this deficit, values are debated in the Design and Technologies subject, where students as designers are more outward-looking as they are expected to entertain "competing considerations" such as economic verses environmental outcomes (with no inferences that one would be preferred over the other).

In Years 7 and 8 students are at the final stage of their mandatory studies of Technologies (ACARA, 2014). Predominately in Middle or High school environments, they are given a greater access to a diverse range of equipment and tools for the realisation of designed solutions. As a result, the expectations of their engagement with these resources is that these students will be able to design, plan and manage projects safely. To accompany this, there are increased expectations of students in both subjects, as student-centred pedagogies allow students take greater ownership of their design process, and exercise informed judgement. In the Digital Technologies subject, there is an increased complexity for design problems that require algorithmic branching and design iteration to test and modify design solutions, incorporating empathy for the user experience, though this can be aligned with economic or social needs, any references to sustainability are not environmentally based. The Design and Technologies subject provides opportunities for an outward-looking environmental focus with references to "present and future needs" (ACARA, 2015, p.2), however what is missing is the essential knowledge and skills needed to satisfy economic needs. Even though this is the last stage in mandatory Technologies education, it is the first reference to innovation and enterprise in the Achievement Standards. This is surprising, considering Technology education is one of the politically focused STEM subjects, and given that the Australian Government has realised the economic benefit of entrepreneurial activities through their 'Innovation Agenda' as "it is not enough just to have great ideas; we must also be able to translate those ideas into products and processes" (DIISR, 2009, p.67).

Following mandatory Technologies studies, the various States and Territories implement a suite of different subjects which are focused on the design process, engineering principles, and specific materials technologies with an emphasis of deepening understanding, and "meaningful and authentic learning" (Snape & Fox-Turnbull, 2013, p.52) experiences. The National Curriculum: Technologies does offer both Design and Technologies and Digital Technologies in Years 9-10, but like other technology education subjects offer in individual States and Territories, they are 'electives'. Arguably too late, but embedded in Achievement Standards for Design and Technologies is a greater focus on designers work practices as exemplars of how design activities can translate to economic outcomes. To support this, there is a reference to the concept of marketing for the first time. There is also an 'outward-looking' economic focus in the elective Digital Technologies subject with an emphasis on assessing risks and security concerns addressing the national research priority of 'Cybersecurity' (Australian Government, 2015), also mentioning the terms innovation and enterprise.

In summary, to capture the diversity and depth of technology education in Australia is not an easy task, as what is explicitly stated in formal curriculum documentation may be only part of what learning and activities actually occur in the classroom as teachers interpret the intentions of the curriculum. What is evident in the National Curriculum: Technologies is an intention to contextualise Technologies concepts through authentic and meaningful learning experiences (Snape & Fox-Turnbull, 2013). It has been discussed that there has been a shift in the focus of the curriculum from an economic focus of developing the individual as a future worker, to the development of the individual to contribute to bettering the three pillars of: society, the economy and the environment. What is explicitly expected in terms of the National Curriculum: Technologies Achievement Standards is a development of the individual to competently design, and engage in an increasingly rigorous process to develop solutions to satisfy identified needs in both Technologies subjects. Whilst this does serve economic goals, there has been an obvious omission in the development of entrepreneurial skills and knowledge that would better serve the countries 'Innovation Agenda' (Commonwealth of Australia, 2018), with a lack of focus in innovation and entrepreneurship in the mandatory years of technology education. Whilst the needs of society have been subsumed into the satisfaction of user needs with an anthropocentric focus, there is an emphasis on virtual communities through networking, networks and collaboration. Whilst there are opportunities for students to learn about the impacts of design activities on the environment, and the incorporation and consideration of environmental criteria, this understanding is the responsibility of the Design and Technologies subject, while notions of sustainability in Digital Technologies are purely a social consideration.

3. Teacher training

The area of Technologies in the curriculum encompasses that of both computing and design and technologies, and Design and Technologies cover knowledge, design and production using materials as diverse as wood and metals though to textiles and food. The general design and technology curriculum covers all students from K-10, with classes in specific areas covering years 11-12.

Teachers of the years K-7 tend in Australia to be generalists, in that one teacher addresses the whole curriculum, Design and Technologies included. The training provided for these teachers varies widely, some courses not addressing this area of curriculum at all and others having a unit or units. Thus, the degree to which teachers are prepared to teach often relies upon prior knowledge (Pagram, Cooper 2017).

The main focus of training for Design and Technologies teachers is in secondary education where specialist teachers are trained to teach the subject. This training can be broken down into those who teach the national Design and Technologies curriculum and those who teach Vocational Education and Training (VET) courses in schools and it ids the former that we will focus upon here. Design and Technologies teacher education in Australia has been undergoing change driven by the National Curriculum. Prior to the introduction of the National Curriculum the training was very dependent upon servicing the various state curricula. School education in Australia is funded and controlled by each state and so has a lot of variation, and the recent introduction of a national curricula attempts to redress this diversity. However, the various States still interpret the national curriculum in different ways, resulting in the maintenance of this diversity.

The diversity varies from those training programs with a design focus to those with a vocational training focus. Now all pre-service education aims to provide teachers capable of teaching a design led curriculum that still requires a high level of workshop competence across a range of materials and processes. The education required to become a Design and Technologies teacher in Australia includes the completion of a degree at university level.

These pre-service courses vary between States, however they can be broken into a number of categories.

- The first is a bespoke four-year degree course with all education taking place within the university environment.
    - This type of course has a mixture of pedagogy, curriculum and practical content units all taught within the university environment, integrated with school based teaching experiences. Less common than in the past this type of course requires extensive dedicated workshop and staffing resources.
- The second course is a hybrid four-year degree course with part of the education (the practical aspect) taking place in a TAFE (Technical and Further Education, a system of tertiary education offering courses mainly in technical and vocational subjects) training facility.

    - This type of course has the pedagogy and curriculum units taught within the university, while the practical skills and other content are taught within the TAFE environment, and is integrated with school based teaching experiences.
- The third is the Master of Teaching/or Graduate diploma that builds upon an existing degree, and is one or two years in duration.
    - This type of course has the pedagogy and curriculum units taught within the university, while the practical skills and other content are assumed knowledge from a prior degree. In some cases, this prior degree is in Design and Technology and in others it is in areas such as engineering, design or architecture.
- The fourth is a conversion course for existing qualified teachers wishing to move into the Design and Technologies area.
    - This type of course is usually intended to help redress a balance within a particular State's education system where there may be too many of one type of teacher a shortage of another (in this case Design and Technologies). Pedagogy and curriculum knowledge is assumed as the participants are already qualified teachers. The courses focusing upon design and practical skills, and other relevant content. The course is usually designed for the specific context.

The graduates of all of these courses are required to seek registration from the various State teacher registration boards, which among other things examine how much teaching practice a graduate has successfully completed and how many content units have been passed. There are also a range of literacy and numeracy standards which students must meet, either on entry to a teacher education course, or on exit in preparation for teacher registration.

These are overseen nationally by AITSL (Australian Institute for Teaching and School Leadership). AITSL provides the local state or territory registration authorities with a set of national standards a graduate must meet in order to become a registered teacher. AITSL accreditation is also required for all Initial Teacher Education (ITE) courses and ensures that all ITE programs align with nationally agreed standards.

In summary there are many pathways into the teaching of Design and Technologies in Australia and with national shortages of teachers in the area, there may be those who are teaching without having been instructed in specialist knowledge, but have enthusiasm for the subject. Because of this the Technologies area is diverse in its interpretation of the focus of teaching - from semi industrial approach to craft focused or design approach. While these variations in the focus of the subject lead to the development of a range of teaching expertise, all teachers have to focus upon the intent of the curriculum which is to develop in students the knowledge, understanding and skills to become critical users of technologies, designers and producers of designed solutions, and citizens capable of critiquing the technological nature and development of the society in which they live.

4. STEM

As Technology (or the Technologies curriculum) represents the 'T' in STEM, developments in this area represent a significant actual or potential influence on Technologies education.

One could argue that the significant STEM discourse in Australia is mainly driven by politicians, and has a workforce planning and economic rationale at its core. Perhaps the key driver for STEM in education is not too dissimilar to that highlighted earlier in this chapter in that governments continue to emphasise the development of skills and dispositions that provide young people 'with an avenue to take an honourable position in society by providing them with means of earning an honest income', and to contribute more generally to the economic wealth and future growth of the country. Williams (2011) reminds us that historically, there is a clear correlation between times of economic depression and significant developments in (technology) education, and further suggests that it is plausible that the global financial crisis of 2007-2009 is the political stimulant for the current STEM education agenda.

The importance of STEM in Australia, from an economic perspective, is highlighted in numerous government reports (see, for example, the Office of the Chief Scientist Australia, 2014). The Australian Bureau of Statistics (ABS) reports that STEM related employment increased by 1.5 times the rate of other areas within the years 2006 to 2011; with design, engineering, science and transport professionals (predominantly engineers and scientists), and ICT professionals showing the highest growth (ABS, 2014a). These reports also identify the need to address the declining numbers of secondary school students and particularly females choosing to study in STEM subjects in the senior years of schooling. In 2010-2011, only 19% of STEM workers in Australia were female, with one in four IT graduates and less than 1 in 10 engineering graduates being female (ABS, 2014b; National Innovation and Science Agenda, 2018). These reports highlight the need to improve teaching in the areas of Science, Mathematics and Technologies, and to ensure that teachers who teach in these fields are trained to do so. The percentage of teachers who teach 'out of field' in Science and Mathematics in Australia is especially high when compared to other countries (Blacker & Howell, 2015; Marginson, Tytler, Freeman, & Roberts, 2013).

In terms of National initiatives, the Australian Government aims for Australia to be one of the top five Organisation for Economic Co-operation and Development (OECD) countries excelling in reading, mathematics and science by 2025 (DECD 2017). It is clear the rationale from which the current STEM agenda has grown is informed by political agendas reflective of economic imperatives. As Blacker & Howell (2015, 103) state, 'STEM has been much heralded as a solution or preventative measure to avoid economic downturns in the future'. However, there is still no clear definition of STEM, and it is contextually interpreted depending on its application: in business and industry, tertiary education, secondary schooling, and elementary schooling, STEM has different connotations.

In Australia the term STEM has continued to gain momentum in education since its inception in the late 1990's. However, the educational rationale, beyond the notion of integration, continues to evolve. In a bid to provide a more consistent and cohesive approach to implementing STEM in Australian schools the Australian STEM School Education Strategy 2016-2026 (2015) outlines 5 goals for increasing student 'STEM ability', these goals are:

1. Engagement,
2. Participation and aspiration,
3. Increasing teacher capacity and STEM teaching quality,
4. Supporting STEM education opportunities,
5. Facilitating effective partnerships and building a strong evidence base for STEM education (Educational Council, 2015, p.6).

Initiatives to support the strategy have included the development of online learning modules for educators, a STEM professional learning exchange, potential changes to preservice teacher education, revision of the Australian Curriculum, establishing a STEM Partnerships Forum and reporting developments within STEM participation and success (Educational Council, 2015). National initiatives have also been established through the Education Council to meet the challenge of immersing and engaging students who are less likely to participate within STEM; females, Aboriginal and Torres Strait Islander students, students from non-metropolitan areas and students with low socioeconomic backgrounds.

While the impetus (and funding) for each of the identified government initiatives can be applauded, closer inspection reveals a disparate interpretation and implementation in schools across Australia, and particularly in secondary schools. Recent reports into the effectiveness of implementing STEM (see, for example the Australian Curriculum, Assessment and Reporting Authority (ACARA) (2018) STEM Report), suggests the following; teaching intentions for content coverage in STEM education were often too ambitious and the depth of coverage of the three learning areas varied. While teachers were generally satisfied with the coverage of Science, Mathematics was the most difficult learning area to plan for, with teachers commenting that they found it hard to integrate Mathematics effectively into projects that were also inclusive of Science or Technologies. Many schools found that Technologies was a key driver of STEM, especially when the solution involved the development of a product. As a result, the number of Technologies content descriptions or identified learning outcomes tended to be high. Of key significance were:

- innovation, enterprise and production skills
- the design process, including
- investigating and defining (design briefs, design thinking)
- generating and designing (communicating possible solutions including drawings, models, prototypes)
- producing and implementing
- evaluating
- collaborating and managing (developing project plans and project management)

While STEM learning can provide an opportunity for solving real world problems through collaborative and individual learning experiences that are hands-on and inquiry-based, adopting a STEM approach to teaching continues to present challenges for teachers who may be constrained by their own perceived strengths and knowledge, or lack thereof, within STEM. Teachers who lack confidence in an area may avoid teaching, or approach the topic with a lack of enthusiasm. Timetabling and planning with different time commitments for sharing resources, and limited professional learning opportunities are also identified as barriers. We know that STEM education is best supported by a whole school approach; emphasising cross-curricular connections, team teaching, and school led professional learning (Educational Council, 2015). Banks and Barlex (2014) suggest further that STEM education can be best 'enacted' where knowledge is shared between educators and the timing of content taught complements content in other subject areas. While this approach of 'looking sideways' may be complex and require negotiation between educators, it is complementary to STEM and can be taught to mutually advantage teachers and better engage their students (Banks and Barlex, 2014, p.37). Furthermore, 'Looking sideways' can be interpreted and enacted more broadly as teachers should be encouraged to continually critique the current political and educational agendas to ensure the best learning outcomes for students.

In Australia the high stakes national testing of numeracy skills via The National Assessment Program for Numeracy and Literacy (NAPLAN) impacts directly on the act of authentically teaching STEM in schools (Blackley & Howell, 2015). As Blackly and Howell (2015, p.106) state, 'It would be a brave school in such a climate of accountability and comparison to step away from the separate curriculum silos to trial STEM education'. There is a growing concern from teachers that areas such as creativity, risk taking and innovation continue to be marginalised in current educational contexts, due to the demand for accountability in terms of productivity and performativity through assessment.

In conclusion, while one could argue that the significant STEM discourse in Australia is mainly driven by politicians and has a workforce planning and economic rationale at its core, it is an argument that can be countered by the opportunities that additional funding and the associated initiatives has the potential deliver. However, there continue to be challenges to overcome for an integrated STEM education to succeed. Williams (2011, p.29) alerts educators, and particularly Technologies educators to 'proceed with caution' when teaching STEM suggesting that it is the need for reform in Science and Mathematics that drives the agenda rather than the goals of Technologies education. The caution here is that Technologies can only become the silent or hidden partner in STEM if we allow it to be. As educators we need to maintain our focus on the possibilities and work collaboratively on the opportunities that potentially STEM presents.

5. The Future

So where to from here? Examining the strategic future of *Technology Education,* as a field of knowledge and practice*,* is a challenging task that historically required entire monographs or edited volumes to capture the possibilities and issues of concern such as the work edited by Williams, Jones, and Buntting (2015).

How we debate and mature our field into the future will be reliant in part on how well we communicate the fidelity of our practice and research. School curriculum will follow a future nomenclature system as it will assist both with the efficiency of teaching and learning as well as reviews of curriculum. Developing a stable and systematic nomenclature for describing how we *design and work technologically* will be a core future concern to avoid misinterpretations. We already see wasted intellectual time trying to explain that 'technology' does not assume a reference to digital or software technologies, as there are many other 'types' of technologies to study. Similarly, creative problem-solving typically combines various types of technologies with non-technical fields to help understand a problem and to design solutions for them. We draw upon language skills, designing skills, scientific method skills, aesthetic principles, social-organisational skills, all in concert to produce technological applications. There is also the issue of project scale, and its purpose and context constraints: the conditionalities that determine a solution's best fit for the circumstance and its primary purpose.

Keirl (2015, p.34) suggests the very name of our field is itself overdue for nomenclature stability advising that when a capital 'T' Technology is used, we ought refer to the umbrella name of the field itself which contains under it, all and any genres (Seemann, 2018) or types of technologies. The small 't' 'technology/ies' are all the families of technologies as recognised by their typical combinations of correlating resources and devices: their tool systems; the material and digital resources those tools were primarily designed to transform, shape, join, divide, move or hold or store; the knowledge and skills required by the acting agents (people) that wield those tools and resources into outcomes; and the primary purpose and context-conditionalities that offer the measures that determine the best-fit of a designed solution.

- Developing a nomenclature for how we define and classify the scope, scale, and finer grain typology of our work will grow as a core concern due to transactional pressures to maximise research and practice efficiencies as well as help refine, communicate the nuances of, and mature our practice.

Technology Education has seen many changes in what the State believes it to be. These range in emphasis from meaning Vocational Education to STEM, or restrictively to digital technology education. While we see curriculum shift and ebb in what the State seeks to emphasise in its sampling and interpretation of Technology Education — design and designing will continue to be a fundamental pedagogical driver to all types of technology teaching and learning. All technologies are the product of some initial fit-for-purpose of application in mind: that is, technologies and their initial intended applications come into existence through processes of design. No technologies exist or see evolutionary development without design playing the lead conductor role in the development, choice, and best fit-for-purpose judgement underpinning Technology Education and practice.

- Design will continue to play its necessary part in any future possibility of Technology Education because *designing and working technologically* (Seemann, 2015, p.101) is a forward looking and integrative intentional act.

In casting to the future of Technology Education, teachers and academics will seek to more effectively organise their forecasts for planning ahead. Identifying useful organisational-frames to explore preferred and sustainable futures will feature in ongoing forecasting efforts in the field. For the purpose of this article, the *Foresight* approach is recommended as an organising framework (Conway, 2008; Pyper, 2003; Slaughter, 1999; Wehrmeyer, Clayton, & Lum, 2002). Relevant to the analysis presented here, is the qualitative scan of the *Casual Layered Analysis* by Inayatullah (2004) for appreciating short, medium and long-term horizons for the field. Importantly, the Inayatullah method demands we accommodate needs ahead via layers of depth and influence. These layers start at the obvious short term, and progressively delve deeper to the current motivations and structural forces directing developments in a field of practice:

- *Litany:* short term, obvious and visible public views, reports and documents. We may include curriculum and education policy focus of the State. Being short term, this layer tends to be temporary and changing, even if compliance oriented.
- *Social causes:* social factors underpinning events and issues being discussed such as socio-economic and 'expert' or 'association' perceptions.
- *Discourse/worldview:* considered deeper structures and common assumptions, with the goal to develop meaning, including understanding how the worldview of participants to help frame understanding of the issues (Conway, 2008, p.9).
- *Metaphor and myth:* the deepest most enduring influence with the goal of identifying intuitive beliefs about the future, and to deconstruct those beliefs to identify what Inayatullah (2003: 8) calls the "civilizational level of identity".

Foresighting includes an environmental scan of the horizon, but it cannot ignore an assessment of fundamental value-assumptions reflected in the way our field perceives itself, its influential voice relative to other areas in the curriculum, and how we have responded to dictums sometimes in a reactionary rather than positional, authentic, and strategic way. There remains a fundamental need to communicate intellectually, demonstrably, and politically the evolving strengths of our field in the curriculum; a strength grounded in our subject's enduring and inalienable purpose as an essential education in and of the made-world.

- Our curriculum identity and authenticity of voice are both very likely to be core future concerns shaping the evolution of Technology Education.

While many popular bloggers and writers highlight the fast-changing impact of new and emerging technologies on societies, these changes are largely driven by capital markets rather than by the sustainable future needs of societies. Those same markets include the political influence for favour in curriculum and initial teacher education priorities. What this structural pattern highlights is that Technology Education is one that is easily highjacked by other actors. Conversations about the core future educational grounding of an education in Technology will see a need to attend to ethical dilemmas. All made-things are products that both draw from and return waste to our habitat, and many made-things are deliberately inserted into the economy to reduce labour costs. Technology is thus an inherently resource cost-benefit field of education, where disruptive innovation is not without a downside. A future education in Technology necessitates an education that fosters an awareness of Technology choice and impact assessment. Ethical technological judgement among learners will rise most likely as a bridle to market enthusiasm for innovations. As all made-things, structures, spaces, and digital or design organic systems mutually and simultaneously depend on both people and habit to exist, a future education in Technology will inevitably mature its systemic knowledge of the *Human-Technology-Environment* system.

- Ethics, especially the forward impact of Technological actions and judgements, will surely rise as a core learning outcome capability to any future serious curriculum in Technology Education.

- The capacity to demonstrate integrated solutions – that account for their ontological interdependencies in a *Human-Technology-Environment* eco-system – will demand ever finer detail of knowledge in the curriculum of the future.

Designing for greater extremes of scale from big-data informed systems to nano-structures will slowly raise school level learning expectations. Such technologies further inform human centred design and are in increasing use to assist urban mobility through our made-world. The rise of data informed human habitats, including the rise of Smart Cities, a future education in Technology is well placed to also assure citizens and visitors are skilled to create, exploit and judiciously navigate emerging urban technologies (Dewalska-Opitek, 2014; Lee & Lee, 2014; Vazquez, Lanero, Gutierrez, & Sahelices, 2018). At the same time nano-technologies have been embedded in our devices with work developments in place for medical nano-technologies to be inserted in our bodies (Flinders University, 2018). The necessity for educating citizens who can take a lead role to both shape as well as critique, synthesise, communicate, and steer themselves through the many layers of our *data rich habitats* will grow as a life-skill not hitherto featured in Technology curriculum but likely to find a new place in it.

- A future education in Technology will very likely be responsive to learning how to design , use and develop technologies at greater extremes of scale: from designing solutions for the urban scale and down to the Nano-scale of medical and repair technologies.
- The rise of the smart city will increase demand for the smart citizen. Such developments now underway world-wide are very likely to also raise educational expectations. In the Australian context, expectations will include how the next revision of the *Technologies curriculum* will foster smart city capabilities in students. The pedagogical challenges range from enabling students to better navigate, create, and also transforming our build environments, to designing outcomes that acknowledge they have to succeed in complex supra-systems responsive to *Big Data* and artificial intelligence systems.

No other area of the Australian curriculum seeks to develop within its learners, purposeful technological self-actualisation, informed by contextually validated knowledge to integrate social, technical and environmental systems through various creative modes of applied design. Now and into the future, no other education seeks to foster that highest of human potential of a kind of applied synthesis targeting real-time skills to develop the intellectual and the material ecology disciplines. The future relevance of the *Technologies curriculum* in Australia, is under historical scrutiny as to whether its next version will show foresight for a generational reform: a reform that foster learners who act in the forward-frame; to design, in order to navigate society, as well as critique and transform it; and generally to graduate active citizens that can make sense of the complexities built around them and upon which sustainable and enriched civilisations depend.

6. Author note

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