



Tinkering With Technology: Examining past practices and imagined futures

Kat Jungnickel

This working paper contributes to [Securing Australia's Future \(SAF\) Project 05](#).

1. What is tinkering?

Tinkering is a socio-technical, material and cultural practice; a curious investigative D-I-Y (Do-It-Yourself) approach to invention that is often compared with the practice of hacking, making or modding (modifying).

Tinkering has been pivotal in a spectrum of applications and disciplines (Levi-Strauss 1962; Latour and Woolgar 1979; Vincenti 1993; Turkle 1995; Biker et al 2003; Nutch 2008; Jungnickel 2013). From grassroots hobbyist contexts to software developers and from engineering offices to science laboratories, tinkering is a practice that is just at home in backyard sheds as it is in STEM contexts. Tinkering is an on-going process and people tinker on a range of things – problems, concepts, experiments, clothing, cooking recipes, cars, broken toasters, mobile apps, phones, store bought furniture and more. It is a hands-on creative multi-disciplinary approach to a problem.

It has been aligned with sustainable / green political agendas for its promise of re-use and re-appropriation of scarce materials. Known as 'part of the inquiring approach to the material world' and 'includes scavenging, scrounging, tampering, adapting, fossicking, fixing' (Thomson 2007:6). It produces a unique result, customised to the user, use, context or task at hand.

Tinkering is also talked about as part of a creative consumption process. The concept of the active or pro-consumer recognises a shift from the passive receiver of goods to one that has agency, creativity and resistance. It recognises that consuming involves the process of tinkering as a means of making meaning and regards 'users' as creative agents of technological change (Lally 2002; Laegran 2005; Oudshoorn and Pinch 2005; Von Hippel 2005; Wyatt 2005). Tinkerers can be classified as creative users in the way they use technologies beyond a single expected application. Lally argues that we 'use objects to manage the social world' (2002:6) and Oudshoorn and Pinch (2005) explain the many uses of a technology that is domesticated through use:

There is no one correct use for a technology. "What is an alarm clock for?" we might ask. "To wake us up in the morning." We might answer. But just begin to list all the uses to which an alarm clock can be put and you can see the problem. An alarm clock can be work as a political statement by a rapper; it can be used to make a sound on a Pink Floyd recording; it can be used to evoke laughter, as Mr Bean does in one of his comic sketches as he tries to drown his alarm clock in his bedside water pitcher; it can be used to trigger a bomb; and, yes, it can be used to wake us up' (2005:3).

Non-users are also recognised for the role they play in technological innovation (Oudshoorn and Pinch 2005; Wyatt 2005). Tinkerers might also be people who resist, reject, mis-use or differently use a device or service.

In terms of technological development, tinkering is often discussed as the means through which people attempt to get inside a sealed or closed system and creatively rework it – either for the

purpose of simply use, to repair or to make it do something beyond that which was intended by its original designer. Yet not all manufacturers welcome this intrusion into their products and services. As Von Hippel has written ‘manufacturers may be concerned about legal liabilities and costs sometimes associated with “unauthorized user tinkering”’. (2005:131).

Tinkering is seen as a valuable skill for innovation. Being able to tinker or mod reveals an ability to adapt to changing circumstances and unexpected happenings; skills highly regarded in a plethora of commercial and manufacturing contexts. Failure is re-defined in the practice of tinkering. Rather than being seen as the end of a process it is re-configured as a creative part of the innovation. To tinker is to test, experiment, make mistakes and keep trying.

The maker movement is built on connected creativity. Australians are no longer isolated do-it-yourselfers (DIYers) tinkering away in their garden sheds. Instead, their extraordinary ideas are connected through social media and in physical spaces such as hacker spaces and maker fairs. Startups are harnessing the value of open source and open standards, using crowd-funding to make things happen (Deloitte 2014:6).

However, tinkering is also imbued with less positive attributes – in some contexts it is associated with lower socio-economic pursuits, low level skills and cheap materials that result in a temporary or amateur fix. As Thomson, in his many studies of Australian shed culture has found, for some tinkering is ‘synonymous with dodgy, low quality, illicit and generally dubious business’ (2007:2). It also features in common parlance as the practice of not quite getting to the core of a problem but rather just operating on the surface. Australia news media provides illustrative examples:

The Business Council of Australia has told the government it's time for proper tax reform rather than just tinkering around the edges - Brinsden, C. (2014) Tax reform must be explained: Parkinson, News SMH, 11 Sept, <http://www.smh.com.au>

Tinkering with education will tear through Australia's social fabric – Pickering, C. (2014) Business Spectator, 26 June, <http://www.businessspectator.com.au>

Historically, tinkering has been associated with economic necessity; interwoven with cultural narratives of creative and imaginative responses to challenging conditions. Its contemporary associations remain similarly conflicted. Regardless of its application, tensions in the form of such as gender, class, race, hierarchies of value, quality, regulation and copyright - remain ever-present. Australia has a long, rich and complicated history with tinkering, which will be discussed below.

This paper investigates some of the social and cultural influences of and in tinkering in relation to contemporary innovation practices and the construction of a spectrum of socio-technical identities.

2. Tinkering's past and present

Although around since the 13th century in the form of a 'tinker' - a itinerant medieval metal worker - tinkering has re-surfaced at the forefront of Westernised popular culture at key moments. Often these are associated with austerity measures which lends a specific force majeure, but has also imbued it with less than constructive associations.

Tinkering was integral to the British 'Make-Do and Mend' movement in the Second World War effort and as a result of the close ties between the UK and Australia had a strong presence in Australia as well. It encouraged Western housewives to frugally attend to scarce resources and rationing with imagination and creativity.

Make Do and Mend was a pamphlet issued by the British Ministry of Information in the midst of WWII. It was intended to provide housewives with useful tips on how to be both frugal and stylish in times of harsh rationing. With its thrifty design ideas and advice on reusing old clothing, the pamphlet was an indispensable guide for households. Readers were advised to create pretty 'decorative patches' to cover holes in worn garments; unpick old jumpers to re-knit chic alternatives; turn men's clothes into women's; as well as darn, alter and protect against the 'moth menace'. An updated version of the book was recently released to coincide with the economic recession, offering similar frugal advice for 21st century families (BL 2014)

Tinkering has gained renewed popular traction in the last decade. Some argue this is again a response to economic necessity. The current 'age of austerity' has prompted many to re-look at mundane and ordinary materials in new ways, develop skills that enable a re-appropriation of materials or join collectives that re-imagine new relationships with conventional consumption and plug-and-play systems and practices.

This version of tinkering is also related to the increasing availability of digital technologies and devices that enable individuals to engage with larger scale practices and tools and showcase their results to international audiences. The opening up of markets and communication channels have meant that individuals are now able to engage in creative activities such as building apps in one's bedroom and successfully selling them on Apple's App Store, fundraising for small ideas on crowd funding sites such as Kickstarter, downloading step-by-step instructions from websites to build the very architecture of the internet in community WiFi networking from off-the-shelf materials and rapid prototyping artefacts using 3D printers in a local hack space or Maker Faire. These assemblies of skills, practices and resources and access to peer-to-peer networking were previously only available to members embedded in much larger scale centres of innovation.

3. Tinkering's promise

- The future of manufacturing

The 2014 Deloitte Report on 'Product Innovation in a Hyper Connected World: The Australian Maker Movement' heralds the promise of tinkering for Australia's large scale manufacturing future.

Although the Australian maker movement is in a comparatively early stage of growth to that of the U.S., the report demonstrates that there are abundant reasons for optimism and excitement about the future of the next generation of inventing and do-it-yourself in this country (Deloitte 2014:5)

The emerging maker movement is the new mineral to mine and the future of industry in Australia (Deloitte 2014:6)

The report's authors view the potential of tinkering for a range of multi-scaled manufacturing operations.

Business would be well advised to observe how the successful startups outlined in this report find ways to participate, learn, and shape the movement. Moreover, we urge Australians to take pride in the emerging movement, which showcases the good old Aussie ingenuity of making things happen (Deloitte 2014:6).

The report usurps the division between differently scaled technologies and the benefits of bottom up innovation.

The scales haven't tipped yet. While alternatives exist to almost any mass-produced item, most consumers haven't yet explored the full range of possibilities. However, it is only a matter of time before large Australian firms begin to feel the impact of this changing landscape through greater experimentation on the part of consumers (Deloitte 2014:8)

There are striking similarities with the rhetoric and hype surrounding the potential and promise of 3D printing for manufacturing success. However, in this case evidence is provided by the growing maker movement around the world.

An alternative model in operation is provided in China, where political support for grassroots technology communities and individuals is present in the form of a new economic space whereby large-scale manufacturers collaborate with small independent makers and entrepreneurs.

What this shows is that makers, manufacturers, and VCs are invested in the "professionalization of make," while approaching it from very different positionality in terms of resources, power and knowledge (Lindtner 2012).

This example debunks the conventional myth of top down technology innovation as sole large scale economic system

- Different models - top down, bottom up, something in-between?

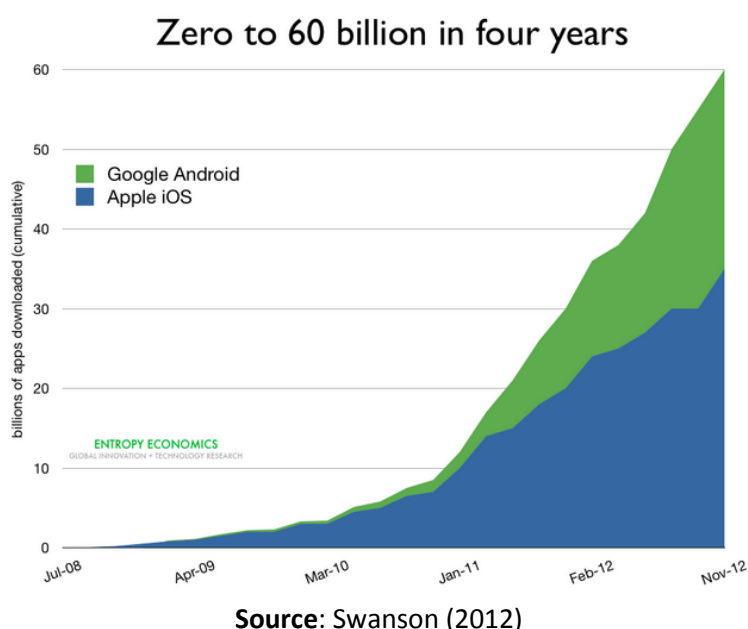
Tinkering, making and DiY cultures unsettle conventional spectrums of small to large-scale institutions, open and closed systems and linear spectrums of success and failure. It offers the opportunity to re-imagine how top-down or trickle-up ideas might produce something not necessarily new but new re-combinations of existing units. For some it forges 'DiY citizenship' and 'democratic participation' (Ratto and Boler 2014; Powell 2012).

For others it is about gaining new entry into previously off-limits markets. The mobile app market is an example of how independent small scale entrepreneurs and countries can gain access and lead the global market with innovative successful products.

Apps' or applications are self-contained computer software programs that address a particular issue or problem that people either download for free or pay for a service. Apps present opportunities for individuals or independent entrepreneurs to gain commercial success in markets previously unattainable outside professionally bounded commercial industry networks.

The App Market - Apple and Android - is a fast growing sector. In 2013, there were over 700,000 apps available on Apple's and Google's App stores and global revenue is expected to rise 62% to \$25 billion (Lessen and Ante 2013).

Swanson (2012) illustrates the massive growth in the mobile app market in 4 years.

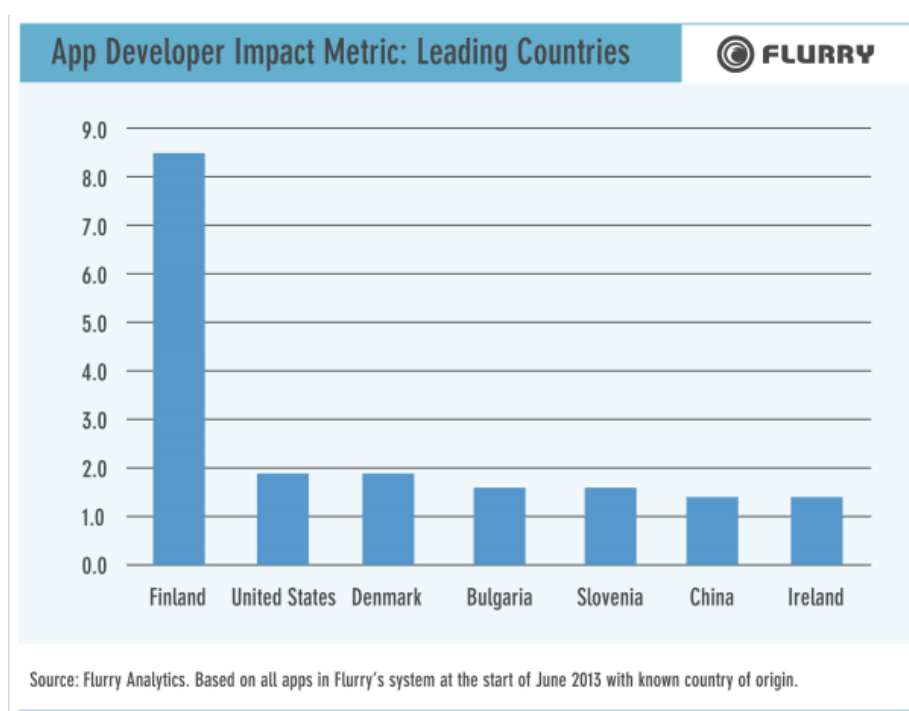


Garter Analysts (2013) argue that 'by 2017, mobile apps will be downloaded more than 268 billion times, generating revenue of more than \$77 billion and making apps one of the most popular computing tools for users across the globe'. Further to its economic value, it is estimated that users spend over two hours a day on apps – this has doubled over the last two years (Flurry data cited by Perez 2013). Australian's are some of the top consumers of both paid and free apps (ACMA 2013).



Source: ACMA (2013)

While the size of the consumer market of each country bears relation to its population, analysts have argued this does not correlate to the impact of App developer impacts on the market. 64% of apps are made outside the US. The graph below shows the disproportionate impact of Finland's 'Angry Birds', highlighting the potential for small countries to make global impact on the market.



Source: Flurry analytics data cited by Perez (2013)

Although a brief overview, what emerges here is that Australia is a big user, downloader and purchaser of mobile apps but currently not a big maker.

- Different kinds of maker business

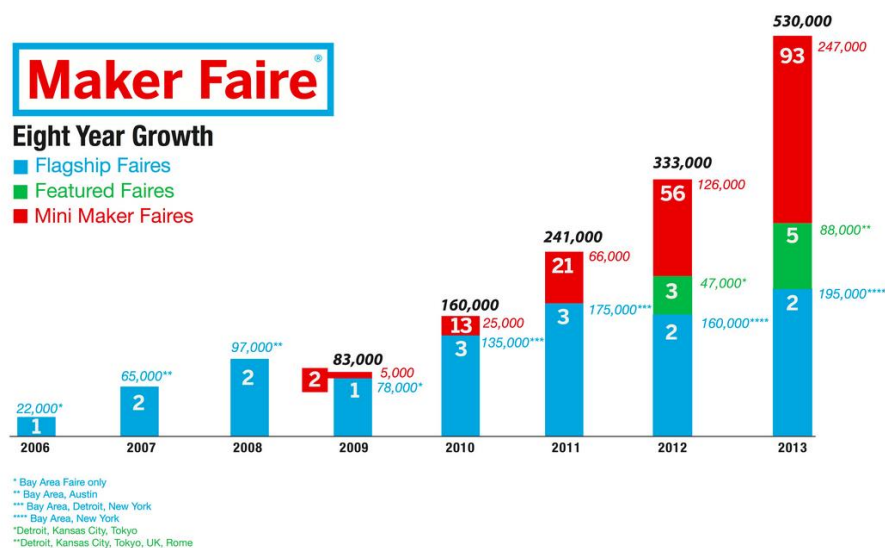
Maker Faires are public events - 'a family-friendly festival of invention, creativity and resourcefulness, and a celebration of the Maker movement (www.makerfaire.com). They were initially created by US based Make Magazine to 'celebrate arts, crafts, engineering science projects and Do-It-Yourself mindset' (www.makezine.com).

The Maker Movement has arguably been around for longer than the recognised output of the Make Magazine series of events but it is popularly viewed as operating as a catalysed and hub for 'technology influenced DiY community' brought together initially through shared online step-by-step projects and increasingly through media spin offs (magazines, maker sheds, products and kits) and events.

The 2013 Maker Faire in New York was attended by 75,000 people with 650 makers and presenters. Maker Faires are now hosted all over the world. In 2013 Mini Maker Faires were held in Adelaide, Melbourne and Sydney.



Source: Locations of Maker Faires around the world - <http://makerfaire.com/map/>



Source: Growth of Maker Faires 2006-2013 - <http://makerfaire.com/>

Maker Faire organisers argue that making is not just hobby, something to be overlooked or trivialised and rather should be recognised as having a major economic, political and social impact:

- 57% of U.S adults self identify as makers
- 62% increase in attendance in Maker Faire events from 2009-2013
- The White House held its first Maker Faire in 2014-10-06
- By 2025 the crowdfunding market is projected to hit \$93b
- 200+ hacker spaces exist across U.S
- For every \$100 spent in independent stores, \$68 returns to the community
- 48% of large manufacturers plan to return production to the US from offshore sources

(Maker Faire.com)

- Entangling ecologies of practice

Tinkering, like any practice, operates within existing ecologies of things, people and contexts. The following are examples of how people tinker with existing brands, objects, ideas and problems and raises issues in terms of conventional regulation and commercial boundaries.

Eg. Ikea Hackers - <http://www.ikeahackers.net/>

Ikea Hackers is a popular website started eight years ago where fans of Ikea showcase their creative re-use and re-appropriation of familiar products in new ways. Examples include: DVD boxes become planters, children's toyboxes become stylish office shelving, bookcases become sideboard



Source: Ikea Hackers - Examples of Ikea Hacks

Recently, Ikea 's lawyers attempted to close the site down when the owner started to run ads. This was met with a burst of anti-IKEA social media:

If you're like me, you've spent countless hours surfing IkeaHackers, where Ikea fans send in their mods and hacks. You've also probably spent money at Ikea thanks to the site, which has inspired a DIY fervor among its fans. Which is why Ikea shutting down IkeaHackers this weekend over trademark claims is beyond boneheaded. Now, Ikea is sending a message that there's only one way to put together its products, and it's written in pictograms on the paper they come with. It's petty and tone deaf, a rare misstep for a company that has a knack for good PR. Instead of encouraging a blogger who has spent years creating what amounts to free publicity for Ikea—and helping people find more reasons to buy products they may otherwise have overlooked—the company is bullying her over a tiny amount of advertising revenue - <http://gizmodo.com/why-ikea-shutting-down-its-most-popular-fan-site-is-a-g-1591401344>

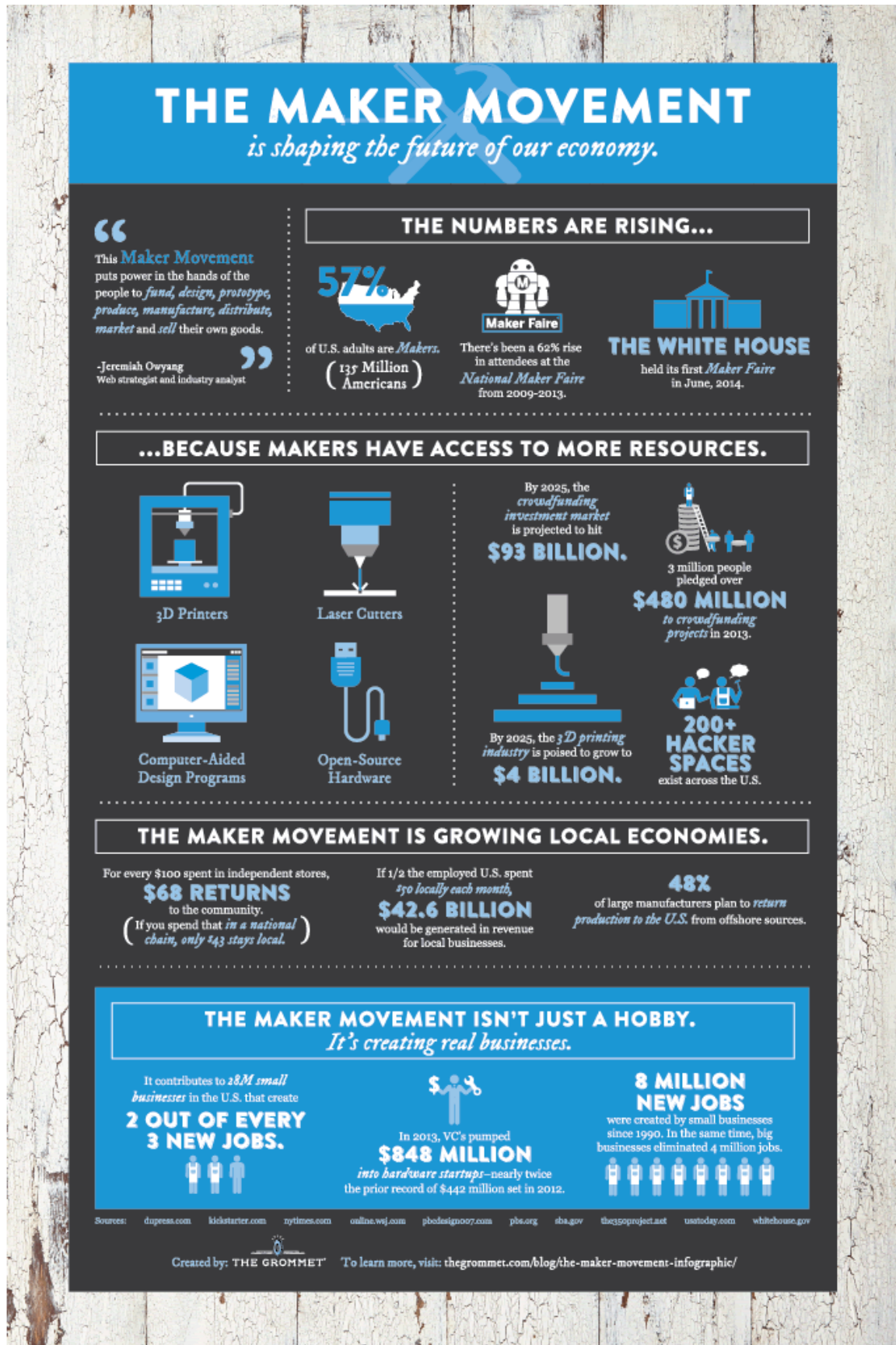
Ikea's C&D is, as a matter of law, steaming bullshit... The fact that money changes hands on Ikeahackers (which Ikea's lawyers seem most upset about) has no bearing on the trademark analysis. There is no chance of confusion or dilution from Ikeahackers' use of the mark. This is pure bullying, an attempt at censorship - <http://boingboing.net/2014/06/15/ikea-bullies-ikeahackers-with.html>

The issue was resolved by the owner accepting Ikea's terms. Small ads were removed from the site. Sine have argued that damage was done to the Ikea brand in the process, that users were not damaging the brand but augmenting it with alternative applications of use. They were re-appropriating and modifying products in their contexts of their everyday lives and encouraging more people to think creatively about their own use of Ikea goods. This example is illustrative of large corporation blindness to the power and promise of the creative user or tinkerer.

Von Hippel (2005) has written about the creative potential of 'lead users'. The IKEA is an example of how a large successful corporations fail to register the possibilities of innovative tinkerers.

Manufacturers design their innovation processes around the way they think the process works. The vast majority of manufacturers still think that product development and service development are always done by manufacturers, and that their job is always to find a need and fill it rather than to sometimes find and commercialize an innovation that lead users have already developed. Accordingly, manufacturers have set up market-research departments to explore the needs of users in the target market, product development groups to think up suitable products to address those needs, and so forth. The needs and prototype solutions of lead users—if encountered at all—are typically rejected as outliers of no interest (2005:15).

Yet, there is evidence to show how lead user innovations can not only socially but also financially benefit large-scale corporations. Von Hippel (2005) provides the example of 3M who embraced lead user innovations and were rewarded with 8 times sales forecast for this period.



Source: <http://makerfaire.com>

- Promise of cross-pollination

For some, tinkering's valuable contribution lies in its potential for cross-pollination. The OECD Report '21st Century Technologies: Promises and perils of a dynamic Future' argues that one of the promises of future technologies lies in people's ability to work across disciplines rather than in silos of practice.

But perhaps the most dramatic breakthroughs in the not-too-distant future will be achieved through combinations of various scientific disciplines (OECD 1998:12)

Fab Labs are a good example of this in action. Started in 2001 in Massachusetts Institute of Technology (MIT), Fab Labs are open source collective not-for-profit printing and fabrication workshops. There are now 200 Fab Labs around the world in 40 countries. The first one in Australia was opened in Adelaide in 2012.

It is free to join and open to all members of the community - students, inventors, hobbyists, small businesses, designers and artists. Members book sessions to use a range of technologies such as the laser cutter, 3D printer and vinyl cutter. In return members are required to 'give something back as per the Fab Lab Charter' (www.fablabadelaide.org.au) which ensures skills, ideas and inter-disciplinary approaches to projects are showcased and shared.



Source: <http://fablabadelaide.org.au/>

- Opportunity to redefine success and failure

Related to cross-pollination is tinkering's opportunity to re-define conventional linear ideas around success and failure.

'Fail fast, fail often' is the well-known mantra of silicon valley startup culture. Although some argue that this is also part of the hype and rhetoric of the culture, it nevertheless exists as a powerful driver for risky entrepreneurial behaviour (Ashgar 2014; Carroll 2014).

As an example: In my study of the largest community wireless network in Australia I found that being able to tinker reveals ingenious and resourceful responses to problems (Jungnickel 2013). Tinkerers enfolded materials 'at-hand' and incorporate improvised methods; a practice entangled with

experimentation that emerges from a deep understanding of the properties of material, place and personal skills. Because breakdown, mistakes and malfunctions are built into the wireless networking systems they are not considered interruptive in the traditional sense of the word. Interruptions do not happen to the WiFi network, they are part of the network. They do not cause failure but rather provide opportunities for members to learn about the technology and adapt the system. Several of the inventions would be considered inefficient at best and failures at worst if read in relation to the desire for, and expectation of, constant connectivity touted by conventional technological models. Yet conventional parameters of success and failure, or even start and finish, are inadequate for understanding how members assess their activities and determine what is valuable or not.

- New ways into the black box

The 'Black box' is a physically or conceptually sealed technological artifact or system. Many have argued that once paths of innovation and use become established they are harder to change than when they are fresh and new (Latour 1987; Graham and Thrift 2007). It is not long before they appear as if they have always been there – like a black box. This state is 'characterized by perfect order, completeness, immanence and internal homogeneity rather than leaky, partial and heterogeneous entities' (Graham and Thrift 2007:10).

Tinkering presents a way of gaining entry into the inner workings of an artefact or system, to interrogate seemingly closed systems for their sociocultural, gendered, historical and material composition. This positionality in turn generates questions such as why we 'get the technologies we deserve' and how and in what ways they 'mirror our societies' (Bijker and Law 1992:3). It also offers a way to re-configure or change the affordances of a technology.

Writing about the advent of the American car industry Franz argues that women's development of mechanical knowledge enabled them to not only drive, but also repair their cars and in doing so gain more independent freedoms than previously possible. 'Tinkering allowed them to participate in a larger discourse of technological enthusiasm and ingenuity' (Franz 2005:11).

Getting into the black box blurs the division between producers and users, providing a response to Google's question to Australians – 'do we wish to be a nation of creators of technology— or just consumers?' (Google 2013).

4. Approaches to tinkering

- Adaptation as invention: the value of tinkering in a global context

English-Lueck's (2003) study of New Zealand's Silicon Valley which highlights the value of different kinds of innovation cultures outside large-scale technology hubs. She shows how local, imaginative and often adapted innovations are not trivialised or overlooked but rather highly valued in the global technology marketplace.

Known for studying the cultures of Silicon Valley in California, she turned her attentions to New Zealand to explore its role as a silicon producer in the global economy. Although very different to Australia in terms of population, economic dependencies, weather, and indigenous culture, New Zealand shares common narratives emerging from isolation, distance and colonial encounters and thus I argue it is relevant to compare technical cultures. Of particular note is how English-Lueck identifies and recognises the legitimacy of a local hands-on approach and links it to high technology production in what she terms a ‘cultural tradition of “inventive-ness”’ (2003:2). She explains the basis of this distinctiveness:

The last stop out before Antarctica, New Zealand has created a narrative around being at the ‘ends of the Earth’. A tolerance for quirkiness is something that informants viewed as integral to New Zealander’s ability to innovate. Niche research and development are key to New Zealand’s place in the global silicon network (2003:4).

Here, New Zealand’s isolation is seen as central to its culture of innovation. Crucially, English-Lueck interprets an aptitude for local ingenuity, adaptive reuse and problem solving as highly regarded attributes in the global technology marketplace. Innovations do not have to be completely revolutionary or new, instead value is perceived in unique re-combinations of existing materials and problems.

- Demand for new skills

There is increasing recognition of the skills required to be involved in these markets. A recent report ‘The Startup Economy: How to support tech startups and accelerate Australian innovation’ produced by PwC and commissioned by Google argued that the Australian technology start-up sector could contribute an extra \$109 billion to the economy and 540,000 new jobs by 2033.

Digital technology and computer science have changed Australia in many ways in the last decade, and these changes will doubtless continue into the future. But as these technologies become more and more integrated into our lives, we must ask ourselves: do we wish to be a nation of creators of technology— or just consumers? We’re already among the world’s heaviest users of tablet devices and smartphones—but knowing how to play games on a tablet is not the same thing as knowing how to create them. One costs money; one generates money. Shifting our focus as a nation from the consumption of technology, to the creation of technology, will help us compete in an increasingly global and connected world (Google 2013)

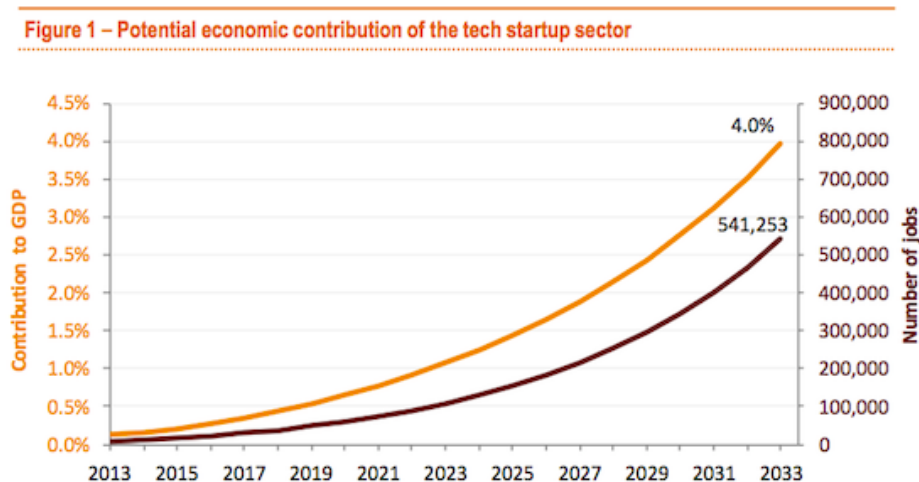
This kind of discourse is triggering debate around Australia’s future. ‘From the Mine to the Mind: Australia’s Economic Future’ by Melouney (2013) is an example of a report that explores a shift from a resources-dependent model to one that draws on Australia’s ‘budding tech startup community’.

In May, the Australian government said that capital investment in the mining sector, which makes up nearly 9 percent of national GDP, may have peaked this spring. Overall economic

growth slowed to 2.5 percent last quarter from a decade-long average rate of 3 percent, despite the fact that the Reserve Bank of Australia has cut interest rates by two percentage points since 2011 to help spur growth. “Australia has no room for complacency,” Greg Evans, chief economist at the Australian Chamber of Commerce and Industry told The Financialist. “We’ve seen the dividends from the mining boom, but in order to lock in those benefits, the rest of the economy needs to become more effective” (Melouney 2013).

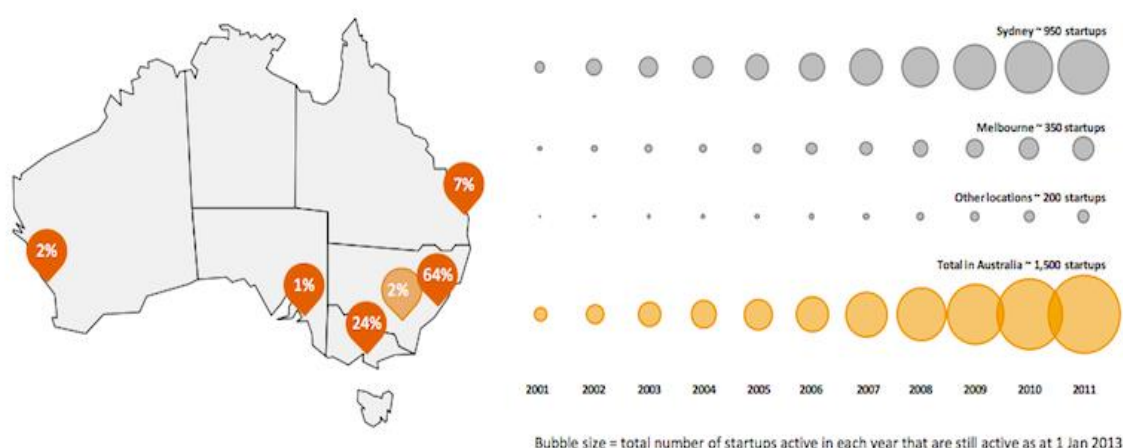
For this to happen a ‘cultural change’ is required which includes ‘greater education directed towards entrepreneurship as an acceptable career path’ and addressing the ‘fear of failure’ that ‘dogs Australians more than people from other nations’ (Hurley 2013). The anxiety underlying this initiative fortifies the notion that Australia languishes behind the rest of the world, content to consume rather than produce.

Google argues that the answer lies in training students in the fields of digital technology and computer science and has petitioned the Government to mandate computer science classes from kindergarten until 10th grade. While this urgency is interesting, it is worth casting a critical eye on the specific skills that are being valued as central to entrepreneurial success.



Source: PwC analysis

Figure 2 – Location of today's tech startups



5. Australian versions of tinkering

- Australia's long complicated history with tinkering.

Some believe that, although Australia has been slow to officially celebrate Maker culture, Australians are *natural makers*:

I think there's a real tradition of fixing things and making things and doing stuff in our shed. I think Australia naturally is a nation of Makers... I don't think we've termed ourselves that before: it's been words like tinkerers or that kind of thing, but the term Maker is fairly new. I think we're Makers anyway. We have a culture of - particularly people in country or remote areas, they have to fix things... They need to fix stuff and mend stuff and naturally we have a tendency towards being fixers and menders and tinkerers (Balinski 2013).

This quote comes from a review in *Manufacturers Monthly* of the 2013 Adelaide Makers Faire. Although regularly run around the world, especially in US, it was the first of its kind in Australia.

The writer is not alone in re-iterating a 'natural' cultural fit between Australian's and tinkering. In this section I explore the etymology of this popular narrative – where it comes from, for whom it speaks and who and what is less visible in this technological imaginary. In particular I explore the positive and negative associations of tinkering in Australia.

- Positive associations of tinkering

There are many distinctly Australian versions of tinkering as a positive technological approach and ideology. 'Making-do' is one from which Australian's as 'natural-maker' emerges.

Making-do is a form of technological innovation and adaptation borne of intractable places and conditions and brought to life through cultural narratives of people's relationships with distance and landscape. It emerges from the peculiarities of harsh bush conditions, economic struggles and limited materials of Australia's colonial past. It is also a heroic masculinised narrative. Here, tinkering is a survival technique that fuses local knowledge, ready-to-hand materials and hands-on skill. It is about resourcefulness and innovation using improvised methods. Although white settlers brought tools, building materials and established ways of working to Australia, they had not planned on a fundamental difference: the landscape and ecosystem. Rarely did technology produced in other countries simply work in Australia. Imported tools inevitably required adaptation due to a combination of sharp differences in topography, magnified scale of use and drastic shortage of labour, which gave rise to the practice of making-do with what you had.

Thomson explains:

With transport slow and distances from cities great, an ability to solve any number of small engineering or manufacturing problems was necessary for a farmer's survival. A broken plough could not be repaired by a quick phone call or a part trucked up from the city overnight. The problem had to be fixed through ingenuity and resourcefulness. The aptitude for nifty solutions with a length of fencing wire, a hammer and a piece of 4" x 2" timber is strongly ingrained and widely felt to be some sort of national competitive advantage (Thomson 2002:8).

South Australia, in particular, became renown for agricultural innovations specifically made to address unique local problems. In the early nineteenth century farmers had few problems growing bumper crops in the 'wheat belt', but they had trouble planting and harvesting them. In 1843 local farmers, John Ridley and John Bull, invented the Stripper-Harvester that mechanised the harvesting and threshing of wheat to the point of replacing the work of fourteen men. By 1860 it was widely adopted throughout the country. Another problem for farmers were Mallee stumps that regularly broke plough bolts shipped in from Britain. The Mallee is a particular species of eucalyptus tree found in South Australia renown for its knotty, stubborn root system.

Frustrated with waiting for replacements that were no more suitable than the broken ones in his possession, a local South Australian farmer, Ron Smith, invented the Stump Jump plough which literally jumped over obstacles and 'revolutionised global farming practices by allowing the cultivation of newly cleared land before all the stumps and rocks were removed' (Soker 1993:24).

These examples, although not revolutionary new designs, demonstrate technologies adapted to problems at hand. They reveal an aptitude for adapting to an unexpected environment and improvising with limited materials at hand. Making-do may have started as a method of survival but soon became central to an Australian cultural narrative of resourcefulness and ingenuity. This

‘myth’ story has maintained a strong hold on Australia’s view of its creative potential. However it is also seen to have less positive connotations.

- Countering the negative associations of tinkering

The ‘she’ll be right’ attitude may be denigrated as the blight of Australian industry, but it thrives in the country’s backyards (Thomson 2004:3).

The dismissal of tinkering as legitimate form of invention draws on Australia’s penal heritage with its attendant class implications. As Thomson writes, the ability to tinker is revelled in some contexts and viewed as being a ‘blight’ on Australia’s global reputation, which in turn points to the often incommensurate nature of ‘home-brew and high-tech’ (Jungnickel 2013).

There are several ways in which this has been discussed in analogous contexts. In a study of ham radio operators Haring (2005) suggests that socio-economic judgements play a role in the trivialisation, total rejection or subsequent erasure of tinkered technologies. She observed how many hobbyists used their involvement in amateur groups as training for and access to the radio profession and associated industries. In identifying the division between people who learnt technical knowledge in classrooms and others who learnt from experience on shop floors or on their own, she writes of the distinction between an ‘association of study with the wealthy and of tinkering with the working class’ (2005:90). What the nature of this dispute reveals is the tension inherent in the relationship between tinkering and innovation and signals that hands-on does not naturally intersect with high-tech.

Another way to view this is through what Henderson calls the ‘aura of high tech’, which she argues shapes how engineers work and represent themselves (1999:196). She describes how important sketches are not only to the generation, collaboration, negotiation and presentation of ideas but how crucial they are to the building of objects. This is how engineers tinker with ideas in their practice. Yet, while tinkering is how many professionals like engineers actually ‘do’ work, it is not how they like to publicly represent themselves. Henderson writes about the realities of ‘messy practice’ and the visual techniques enrolled that keep them hidden from outsiders, in order to preserve the ‘mystique’ of the discipline (1999:185). The idea that ‘daily practice kills the aura of high tech’ explains why engineers were embarrassed when she observed the messy reality of their design process (1999:193).

The aura of high tech and the use of new technologies such as CAD as symbolic tools in engineering continue to add status through the mystification of the mundane and messy work practices that are necessary to accomplish the goals of the job (1999:196).

Thus, a crucial aspect of tinkering is the clear distinction rendered between the messy behind the scenes process and the professional public worldview. Martinez and Stager (2013) also consider the messier practice of tinkering. They discuss how critical learning experiences come from a hands-on engagement and experimentation with materials. They question why conventional educational practices tend to separate theory from practice and art from science when real life is much messier

than these neat categories. ‘Tinkering’, they write, ‘is a uniquely human activity, combining social and creative forces that encompass play and learning’ (2013:85).

“Tinkering, Engineering, and “Real Work” (Martinez and Stager 2013:42-43)

“It seems that to many people, tinkering connotes a messiness and unprofessionalism that doesn’t apply to “real” jobs in scientific fields.

I believe just the opposite is true – tinkering is exactly how real science and engineering are done.

I like to think I have a unique perspective on this. After graduating from UCLA with an electrical engineering degree I went to work at an aerospace company on a research project to create the world’s first GPS satellite navigation system. It was fun, exciting work because we were building something that we knew would change the world. The task was literally theoretically impossible, which made it even better. The hardware was too slow, the software didn’t exist, the math was only a theory, and existing navigation systems weren’t built to handle what we needed. I was thrown together with an assortment of mathematicians, scientists, hardware gurus, engineers, and programmers who weren’t used to working together. The military pilots we collaborated with didn’t trust any of us or our new-fangled ideas, which created even more interesting team dynamics. There were many days when we just sat around and talked through the problems, went to try to them out in the lab, and watched our great ideas go up in smoke. Then we did it again...and again...and again...until it worked.

It was the essence of tinkering. We tinkered with ideas, methods, with hardware and software, always collaborating, always trying new things. There was no “right answer,” no “scientific method,” and sometimes the answers came from the unlikeliest sources or even mistakes. There were flashes of insight, fighting, battle lines drawn, crazy midnight revelations, and the occasional six-hour lunch at the local pool hall.

My flash of insight, 20 years later, is that perhaps we should avoid squeezing all serendipity out of STEM subjects in a quest to teach students about a “real world” that exists only in the feeble imagination of textbook publishers. Tinkering is the way that real science happens in all its messy glory.”

- Gender and tinkering

Some critics question the relevance of Australian’s stubborn historic version of tinkering to a contemporary and constantly changing multi-cultural society. For instance, some view making-do as associated with male identity. Jackson notes how ‘many writers have referred to ‘rough and ready’ local designs with a certain measure of pride, as if this characteristic in some way attested to their masculinity’ (2006:253). Few of these classically heroic narratives of ‘making-do’ feature women’s stories. They are also primarily concerned with engineering feats and exploits. What is absent in these version of ‘making-do’ are varied stories concerning more of the domestic arts and technologies such as sewing, cooking, cleaning, caring for others etc.

Critically, these are not historic issues but alive and well in contemporary versions of making and tinkering imaginaries. An illustrative example is the Deloitte (January 2014) Maker Movement report, which although gender neutral in its writing overall visually represents only men with technology in its imagery and gives voice only to male makers and innovators. Women do not feature.

In their study of robot builders and professional software developers, Kleif and Faulkner (2003) write about how ‘boys are more likely than girls to be socialised into hands-on tinkering with mechanical devices’ (2003:297). Much like my arguments in relation to 3D printing, tinkering often appears in many ways gendered male, even if this is countered in practice. Questions need to be asked about this stubborn technology practice of representation, especially when key market players present images of themselves and narratives that firmly reflect and produce particular gendered versions of the technology use and its potential users.

Further to being gendered and disciplinary, Jackson argues that ‘making-do’ is colonial, white and associated with the Australian outback. He calls it a ‘myth’ and a ‘national delusion’ and takes particular grievance that it is still a widely accepted and celebrated approach to Australian innovation and design some 200 years after its British inception. He considers it unreflective of an advanced multi-cultural society. Writing about Australia’s bicentennial celebrations in 1988: ‘It is rather sobering, however, that the rural white male constructs of the Australian national identity were still promoted by the Australian popular media and as recently as this’ (2006:251). Highlighting the suburban reality of Australian life he questions why there are far fewer representations of innovative Australians as urban ‘hi-tech people’ (ibid).

There are exceptions. Images from the successful Maker Faires regularly showcase a range of makers and Fab Labs work hard to represent the diversity of users. There are also women’s only hacker spaces and events (Wolfrom 2013). Another example is the award winning 2001 Australian documentary *Bush Mechanics* directed by David Batty and produced by the Warlpiri Media Association that tells the daily activities of a group of young aboriginal men from the Yuendumu community in remote Central Australia and how they deal with the constant challenges presented by cars in the outback. This documentary presents contemporary instantiation of making-do. While this example pushes back on the white-ness of historicised making-do narratives, it does less to recognise the reality of tinkering in Australia’s diverse, urban, multi-cultural citizenship. Hawkins (2005) writes:

Funny, innovative, and full of self-parody, Bush Mechanics reveals a completely different set of car practices from those usually seen and celebrated on commercial TV. There are no high-speed chases here, no glossy celebrations of the car as commodity fetish – rather, a set of madcap adventures about driving in the desert in cars chronically on the verge of mechanical collapse. The main content comes from watching these “bush mechanics” solve a variety of technical problems using whatever they can lay their hands on. Punctured inner tubes are replaced with densely matted spinifex grass, brake fluid is made from laundry detergent mixed with water, replacement parts are found on abandoned wrecks that are part of the collective memory in remote desert spaces. All this is evidence of a playful inventiveness

prompted not simply by need but also by a robust practical knowledge about various ways of keeping a car moving (2005:87).

Taking tinkering seriously into more formal contexts of technology development for Australia's future requires a deep understanding of its past and present and ways in which it shapes its technological imaginary.

- Valuing perspectives from the shed

The Institute of Backyard Studies (IBYS) is an Australian organisation that seeks to bring to light and celebrate an urban and domestic relationship with tinkering. Thomson (2002, 2004, 2006, 2007, 2008) has written at length, and in a scholarly vein, about men, innovation and Australian shed culture: 'Our national knack for invention and innovation, for making do, lives on in the shed' (Thomson 2004:3).

Sheds take many shapes and sizes and shelter a diverse array of tools, materials, machinery and other random things. They are not defined by the specifics of what they hold or even what they are used for but rather in what they enable. Sheds are closely linked to the conflicting meanings of tinkering - Australian DIY ethos of practicality and ingenuity intertwined with a haphazard and less valued approach to repair/adaption.

Bell and Dourish (2006) also examine sheds in suburban culture. They argue that sheds offer critical vantage points into our relationship with technologies - it provides a privileged viewpoint on domestic practices and gendered relationships around technology, enabling new ways to think about socio-technical relationships. Sheds are sites of encounters between new technologies and existing domestic ecologies, at different points in their user trajectory. Artefacts move from the house to the shed when they are broken, unsafe or have lost their initial use. In the shed they are fixed and returned to the house, or dismantled, given a new lease of life doing something new or left in pieces, to gather dirt and dust for the right moment.

In some ways one might also regard the shed as a very real staging point for technologies coming into or out of the home – it is a place for not yet domesticated technologies or for those that must forever remain feral and dangerous (2006:375).

What is interesting here is how tinkering in the shed operates as a lens for looking anew at stuff, that may or may not work as intended, and for imagining new application. '[F]or as much as sheds function as sites of particular activities, they are also a cultural form; an imaginary realm within the larger domestic expanse (ibid). However, what also emerges here is how tinkering is again recognized in domestic environments - in the shed as opposed to the home – and given the attending gendered orientation of the feminised and masculine spaces, draws attention to the gendered nature of the practice.

What this example points to is how the materials to tinker are often within reach of the tinkerer. Inventions do not need to be revolutionary to be valuable. Inventive re-configurations can provide powerful interventions into a seemingly saturated market.

6. Project questions

What are the opportunities, barriers and determining factors for new or different uses of tinkering across Australia's SCDSSES?

Opportunities
• Tinkering promises a way to respond to changing conditions, the tyranny of distance, complexity of supply chains, rising costs and growth of new global digital technology markets – all factors that relate well to the Australian context. It is a familiar term in Australian culture; recognized as being something that Australians 'do' naturally and well. Regardless of the empirical evidence of Australia's 'natural affinity' for tinkering, there is an opportunity to claim and cement this myth for Australia's technological future. • Tinkering blurs conventional barriers between disciplines – such as art and science, theory and practice, work and play. However, tinkering does not come 'naturally'. People can be taught to tinker within education contexts. • Scale is not always defining factor of success. Small is just as important as big when it comes to innovative and impactful technology. Ie - English-Lueck's work on NZ's technological innovation culture in the context of US Silicon Valley. • Failure does not mean the death or end of a project but rather is part of the innovation process and can reveal new ways of thinking about a problem/ task/ solution/ idea. Tinkering does not always result in an innovative solution first time, but mistakes and tangents are part of tinkering and can result in unexpected innovation • Gain a deeper understanding of how and why Australia's Fab Labs are successful model for exposing the broader public to tinkering. Subsequent Maker Faires in Adelaide, Melbourne and Sydney are also prime sites for investigation.

Barriers
• Tinkering is currently under valued as a cultural asset. The negative associations are stronger than the positive ones. • Tinkering can be associated with failure – and reports suggest Australian’s are not as open to failure as they could be. They are penalized for failing rather than being rewarded for risky entrepreneurial behaviour • Skillsets, such as digital technology and coding skills, which are seen as essential to a particular type of entrepreneurial activity (as defined by Google and PwC) are limited • Tinkering is sometimes viewed as being located in key spaces –in backyard sheds or in established ‘maker-spaces’ such as Fab Labs – rather than being something that anyone can imagine themselves doing, anywhere, at any time • Tinkering is often associated with something that comes ‘naturally’ as opposed to something that can be learned or taught • As per 3D printing, the larger ecology of tinkering as a technological approach is, by default, also limited – ie. hubs of knowledge, community knowledge, internet connections, distribution models. 3D printing also requires good ideas, design skills, electricity, software, computer skills, materials etc • Slow internet connections - limited access to online resources • Like 3D printing, tinkering is always and already nested within a larger constellation of forces. It cannot be extracted from the ecosystem of computation, digital literacy, manufacturing, distribution and also a variety of installation protocols.

Q. How should all these questions be considered by Government in an on going fashion in the future?

- There is compelling evidence that the way to teach people better STEM skills is to put it in context and let them play and tinker. Providing encouragement and support to Australian schools and other organisations to facilitate the development of tinkering, including fostering the attitude that it is ok to try and fail, and a refusal to accept the status quo as acceptable, could pay huge long-term dividends for Australia. An Australia where every

citizen is willing to tinker and improve the way things are done will be an Australia that continues to get better.

- Understand the role of the successful collective maker movement in Australia – same, different to US/ China/ UK? How Australians approach tech differently to other cultures – often new adopters or different adopters with different adoption curves and ecologies of use.
- Setup committee with representation from multiple tinkering user groups – large scale manufacturing, small scale business, community groups, hobbyists etc. Explore ways to find middle ground and or learn from shared approaches/ methods/ visions about how they articulate and communicate what tinkering is in different levels of society
- Conduct in-depth study into perceptions and practices of failure in Australia
- Conduct an in-depth study into different models of access/ analogous technologies, and adoption patterns. Ie. How is NZ embracing and enacting a quirky, risky technological identity?

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