(Un)Schooling Gender

Realising the STEM Potential of 'Maker Technologies'

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Master of Educational Leadership

Master of Professional Education and Training

Graduate Diploma of Education (Secondary)

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Bachelor of Arts (Hons)

Thesis submitted as part of the requirements for the degree of Doctor of Philosophy

Faculty of Education
Monash University
June 2021

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Abstract

This thesis addresses the recent rise of Maker technologies and associated forms of 'Maker Education' (Maker Education) in formal school settings. It contrasts prevailing claims over the potential of Maker Education to support gender inclusive (if not female empowering) forms of STEM education with the long-standing observation that technologies used in schools are often 'situationally compromised' (Cuban, 1988), and fundamentally shaped by organisational structures and their underpinning politics of contemporary schooling. Accordingly, this study draws from a range of place-based, material and feminist theories to consider the gendered nature of schools and schooling more fully, and most significantly, develop the idea that girls' engagement with Maker technologies in schools is best understood as deeply embedded in the social world.

The empirical basis of the thesis draws from an in-depth ethnographic case-study of the integration of Maker technologies in one outer-suburban government high school in Melbourne (Greenfield College). Viewing its ethnographic data through place-based, material and feminist theories enables three equally significant analyses: first, how Greenfield College is emplaced within its broader social and political context; second, how contradictory understandings of gender are surfaced through the enactment of Maker Education across Greenfield College; and third, how the school's institutional and pedagogic conditions shape girls' engagement with Maker technologies.

As such, the thesis develops the argument that Greenfield College's enactment of Maker Education is inevitably stymied by the dominant ways in which gender is understood and operates in the school. In contrast, the thesis's investigations also point toward several alternate feminist-oriented interventions that may better realise attempts to lift the number of girls taking up STEM subjects and STEM career pathways using the conduit of Maker technologies. This thesis therefore makes an original contribution to knowledge by exploring the implementation and use of Maker technologies in schools not as a political neutral endeavour but rather as a gendered socio-political exercise that renders schools complicit in creating the very problem they are trying to solve, gender inequality.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Acknowledgements

My thanks go to the Department of Education (Victoria) for permission to conduct my research in a Victorian government school, and to all staff for their candour and good will, as without either, this study would not have been made possible.

I am also most grateful to have received the financial support of a Monash University Faculty of Education Research Excellence Scholarship and the Monash University Research Completion Award (GRCA) which aided my project's completion consequent to the immediate impact of COVID-19.

To my academic panel, I thank you for your support, encouragement, and guidance throughout this process. I am especially grateful to Professor Neil Selwyn for patiently working with me as my principal supervisor, particularly for pulling me out of the numerous rabbit holes I habitually travelled down on my journey toward discovering this study's final conclusions. His expertise, advice, and suggested revisions on my written work is deeply appreciated. I also thank my co-supervisor Dr Carlo Perrotta for his support.

Special appreciation goes to my family and friends, all of whom provided reassurance and space for me to complete this work, figuratively and materially, even when we found ourselves challenged by small places and extended COVID-19 lockdowns. Living through these experiences with you whilst completing this project ensured I learned firsthand the true nature of selflessness, generosity, and resilience from you all. Thank you.

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Glossary

- *3D Learning Technology*: Computer-based technology such as the construction of 3D shapes used for used to create a 3D artefact as an aid in the learning process used for 3D printing, origami, or virtual reality gaming.
- *Coding:* The physical act of writing lines of code to instruct a program on what to do.
- *Computational Thinking Skills (CS):* Skills associated with using a computer or other tools to solve problems by arranging, abstracting, and analysing data; most often consolidating a series of ordered steps, algorithmic thinking, and resources to automate solutions which can be transferred across additional problems.
- *Debugging:* The process of detecting and removing existing and potential errors ('bugs') in a software code that prevents a system, program or device from working.
- *eTextiles:* An electronic craft that combines electronic parts such as LED lights, sensors, or other high-technology pieces with low-technology crafting skills.
- *Fabrication*: To construct, create, and assemble a part with the aid of technology.
- *Maker*: Key attributes of being a 'Maker' include participating in spaces with diverse tools, materials, and processes to explore problems and projects and iterate designs. Notions of community, collaboration, sharing creation and skills, and taking on leadership, mentoring, and teaching roles are also central.
- *Maker Education:* A term coined by Dale Dougherty in 2013 to describe 'Maker Education'; an approach to learning that is problem and project-based, reliant upon hands-on, often collaborative, learning experiences as a method for solving authentic problems.
- *Maker Movement*: The 'Maker movement' refers to the trend in which a growing number of people are engaged in making physical or digital artefacts for use in their daily lives, and then sharing their processes and products with others.
- *Makerspace*: Physical workspaces where individuals use inquiry-based learning practices to explore and expand ideas, problem solve, learn technical skill sets, and produce new learning artefacts or products that can be shared with a wider community. In these spaces, individuals have access to 'Maker technologies.' Makerspaces in schools are understood to encourage students to engage with creative thinking, and both technical and social practices.
- *Making:* For this research study, 'Making' is understood as engaging in a learning process that involves the use of digital tools.

- *Maker Technologies:* Digital technologies used in Making. These fall into three categories: Digital Fabrication, Physical Computing and Computer Programming.
- *MIT:* Massachusetts Institute of Technology.
- *STEM:* Science, Technology, Engineering, and Mathematics.
- *STEAM*: Science, Technology, Engineering, The Arts, and Mathematics.
- *Tinkering*: A sub-category of 'Making' characterized by improvisational, creative problem-solving.

Chapter 1. Background and Rationale

This thesis addresses the recent rise of Maker technologies and associated forms of 'Maker Education' (Maker Education) in formal school settings. It aims to contrast prevailing claims over the potential of Maker Education to support gender inclusive (if not female empowering) forms of STEM education, with the long-standing observation that technologies used in schools are often 'situationally compromised' (Cuban, 1988), and fundamentally shaped by organisational structures and their underpinning politics of contemporary schooling.

For just over a decade, there has been growing interest expressed by governments, business groups, the media and educators related to bringing the 'zeitgeist' (Davies, 2017) of 'Making' (Making) into K-12 schools. Described variously as a set of activities related to 'creating something' (Hsu et al., 2017) or 'designing, building, modifying, and/or repurposing material objects, for playful or useful ends' (Martin, 2015, p.31) or something 'that can be designed with a variety of learning goals in mind [that] can happen in a variety of places' (Halverson & Sheridan, 2014, p.501), student 'Makers' (Makers) engage with the activities of Making work in 'Makerspaces' (Makerspaces), areas set aside for students to create self-directed passion projects, prototype inventions, and learn new computer thinking skills, engineering and design practices.

Student Makers partaking in Maker Education participate in a form of learning that purports to be not so much about the 'stuff or the high-tech tools' associated with digital fabrication, physical computing or programming but rather the 'mindset – thoughts and actions related to creativity, innovation, ingenuity, out of the box thinking and self-directed learning' (Gerstein, 2016, p.16). Here amongst proponents of Maker Education there exists broad uncritical acceptance that student engagement with Making and Maker Education is a viable mechanism to attract more students to engage in science, technology, engineering, and maths (STEM) subjects and/or career pathways, particularly girls.

Yet although Maker Education has now been championed by governments and other vested interest groups for many years as a viable solution to correct the 'sex imbalance in STEM' (Bickerstaff, 2005, p.369), government efforts to recast and market STEM in a girl-friendly or 'pink' (Heybach & Pickup, 2017) manner through the vehicle of Maker Education have again 'failed to adequately take up feminist theory' alike to the 'girls in STEM' and 'corporate women in STEM' intervention programs (Heybach & Pickup, 2017, p.614) that have been running in schools for many years. Accordingly, the

intention of the present study is to redress the atheoretical 'blind spot' described by Heybach and Pickup (2017) - albeit applied to Maker Education scholarship - by exploring more deeply the implications of gender in schools investing in Maker Education.

Before doing so, however, an overview of existing Maker Education scholarship in K-12 school settings is first provided to situate the present study and its contribution to Maker Education scholarship. As such, this first chapter provides an overview of the type and range of 'Maker technology' (Maker technology) tools used in schools, the perceived benefits of students engaging with Maker technologies and the barriers that accompany Maker technology implementation efforts in schools.

1.1 Introducing Maker Education scholarship

Although in recent years there has been increasing scholarly attention paid to the phenomenon of Making in museums, libraries, and after-school programs, few studies to date have sought to explore the troubled space that exists between the so-called educational potential of Maker technologies in schools and the lived reality of individual classrooms or school settings more generally (Godhe et al., 2019). Indeed, with few exceptions, most research focused on Maker Education in school settings extols the pedagogical affordances of Making, celebrates the promise of a class of activities whereby staff create objects, many of which incorporate technology, all the while acquiring Computer Science Thinking (CS) skills. Moreover, most studies start from the premise that student engagement with Maker technologies offers the educative potential to enhance student learning and cognitive development (Halverson & Sheridan, 2014; Martin, 2015) by facilitating greater learner engagement with technologically complex production processes (Blikstein, 2013) in a more authentically interdisciplinary manner than ordinary classroom practices (Martin, Dixon, & Hagood, 2014). Accordingly, to date most research on Maker Education in schools can be categorised into four main areas:

(1) the projected outcomes/impact of Maker Education in terms of engagement and motivation, particularly in STEM activities for school aged students
(2) descriptions of student Maker Education activities
(3) emerging design principles and pedagogies associated with Maker Education learning programs
(4) the potential of Making as an educative practice to influence equity-oriented education

Less visible are studies exploring the recommendations of projects such as Paulo Blikstein's (2013) *FabLab@School* which calls for the careful 'inclusion of Maker technologies into classrooms and curriculum designs' (Cohen et al., 2017, p.217) and those very few recent studies (Godhe et al., 2019; Perotta et al., 2018; Nemorin & Selwyn, 2017) that consider the social, cultural and political contexts of everyday schooling in their study of Maker Education in schools.

1.2 Maker technologies used in schools

The use of Maker technologies in schools begins from the proposition that tools and materials are important components in learning. As such, Maker technology tools and materials—for example, computers and peripherals such as screens and scanners, inkjet and 3D printers, and electronic circuits with sensors and lights—are considered a subset of a broader suite of technologies that contribute to learning. The most common Maker technologies described in the emergent literature can be broadly distinguished using the utility typology offered by Martinez and Stager (2013): Digital Fabrication Maker technologies, Physical Computing Maker technologies and Programming Maker technologies**.**

Martinez and Stager's (2013) first category – Digital Fabrication Maker technologies - includes Maker technologies that allow students to design and build real-life objects. This category includes 3-D Scanners, 3-D Laser cutters and 3-D Printers. Popular models found in schools due to their reliability and affordability are 3-D scanners such as the *Makerbot* digitizer (Martinez & Stager, 2013) whilst 3-D Laser Cutter Digital Fabrication Maker technologies used in K-12 school settings include *ShopBot, Brook Drumm*, *Printrbot, Makerbot* and *Ucube* (Leduc-Mills & Eisenberg, 2011).

Studies focused on schools using these Maker technologies report several student learning benefits. These include the way 3D learning artefacts make abstract concepts tangible for students as well providing a means for students to express their learning through the building of personalised models (Thornburg et al., 2014; Mellis & Buechley, 2012). However, much of the literature also reports a range of logistical challenges. These include safety concerns arising from student exposure to hot parts, fumes from melting plastic, students hurting themselves when removing parts from the printer base and the slow production of learning artefacts (Thornburg et al., 2014, pp.6 -7).

Martinez and Stager's (2013) second category - Physical Computing Maker technologies – includes Maker technologies used to create machines that interact with their environment. These are

becoming increasingly common in school settings and are used to teach students to design, construct and program 'smart' machines that function outside the computer and interact with the 'real' world. Studies of Physical Computing Maker technologies report some educators holding the belief that Physical Computing Maker technologies provide tactile contexts for the introduction of STEM science and engineering career pathways as it these Maker technologies that promote opportunities for students to build, debug hardware and software, improve and/or embellish existing operational machines (Telhan et al., 2014). Common Physical Computing Maker technologies used by primary and middle school students include *MaKey MaKey* (Schwartz et al., 2015), *Drawdio, Minty Boost*, and *TV-B-Gone* (Martinez & Stager, 2013).

More complex Physical Computing Maker technologies targeted at older students are often implemented in schools to introduce students to microcontroller programming which invites students to engage in the complex worlds of engineering and robotics. Examples here include: *ATTINY85* microcontrollers (Qi & Buechley, 2014) and *Raspberry Pi* (Harnett et al., 2014). More common still are *Arduino* open-source electronic microcomputer microcontroller kits (Harnett et al., 2014; Mellis et al., 2013) and *Modkit* (Qiu et al., 2013). For schools investing in e-Textiles, the two most common Maker technologies are *Lilypad Arduino,* a wearable computing microcontroller (Kafai et al., 2014; Searle et al., 2014) and *Flora* wearable computing construction materials. Examples of Physical Computing Maker technologies used to promote robotics in schools include *PCDuino*, *LEGO Wedo* (K-2) or *LEGO MindStorms NXT* (8-12) robotics construction kits which are designed to enable learners to operate their robot creation untethered from the computer (Lane et al., 2013).

Finally, Martinez and Stager (2013) suggest their third category of Maker technologies - Programming Maker technologies – represents 'the nervous centre of the Maker revolution' (p.132). This view is supported by Papavlosopoulou, Giannakos and Jaccheri's (2017) literature review which confirmed that a 'Making approach to learning' is used most notably in computer science programming curriculum areas (p.62). Here students must learn programming languages when working with microcontroller boards such as *Arduino* and *Raspberry Pi* (Martinez & Stager, 2013). Other programming language options found in the literature include *Java*, the language used in post-secondary Computer Science courses (Jacobs & Buechley, 2013); *C++*, a programming language used

widely in business and industry; *Processing*, a free open-source language for programming visual images and animations; *BASIC*, a programming language popular with beginning programmers since the 1970s; and *Python*, a free programming code often used on the *Raspberry Pi* that is well-supported by online user groups, libraries, project examples and tutorials.

Additionally, the popularity of Programming Maker technologies is also often attributed by scholars to the commercial range of interdisciplinary creativity toolkits that commercial providers have purposefully developed to engage primary and middle school students. These include *Simulation Creation Kit* (Basawapatna et al., 2013), *Stagecraft Creator Software* (Denner et al., 2012), *Maker Theater* (Chu et al., 2015), *Mobile app Makers* and *MIT App Inventor* (Burge et al., 2013) and Gaming Programming Maker technologies such as *GameMaker* (Khalili et al., 2011), *Gamestar Mechanic*, *Codespells* and *Kodu,* a visual programming tool made for creating XBox games that use a game controller for input (Esper et al., 2014a; Esper et al., 2014b).

1.3 Why use Maker technologies in schools?

Much of the existing empirical research focused on the use of Maker technologies in school settings is instrumental, often citing four main reasons to explain the implementation and use of Maker technologies in formal school settings:

(1) developing student Computational Thinking Skills (CS).
(2) developing student STEM conceptual understandings and skills.
(3) assisting soft skill development (21st Century Skills).
(4) expanding student interest from non-dominant cultural groups and girls in STEM subjects and career pathways.

In the first instance, the literature affirms there is a close connection between efforts to promote interest in Computer Science and the use of Maker technologies in school settings (Blikstein, 2013; Dixon & Martin, 2014). Wing (2006) suggests that like many other introductory computing curricula that provide a context for computing (Baretto & Benitti, 2012; Biju, 2013), engaging learners with e-textile Maker technologies develops computational thinking skills such as learning computational concepts, computational practices, and developing computational perspectives. In this regard, a study undertaken by Brennan and Resnick (2012) identified three common computational

perspectives that learners develop through programming interactive digital media. These include learning how to create something that allows for self-expression through computation, connecting with others to make something computational in collaboration with others for an authentic audience, and developing the skills to ask questions of and with technology.

Also affirmed in much of the Maker Education scholarly literature is the idea that using Maker technologies in schools helps students develop STEM conceptual understandings and practices. For example, Martinez and Stager (2013), Dougherty (2016) and Gershenfeld (2012) assert that learning by Making has the power to reshape the traditional provision of STEM in schools which otherwise often renders students' passive consumers of knowledge, focused on rote reproduction of knowledge, that is too far removed from students' everyday lives (Blikstein, 2013).

Affirming the value of Making and Tinkering in out-of-school STEM learning environments is Vossoughi and Bevan's (2014) extensive summary of research which focused on how Making experiences can impact youth interest in, engagement with, and understanding of STEM subjects. Findings here highlight the notion that student engagement with Maker technologies can enhance young people's participation and sense of belonging in STEM by supporting new intellectual dispositions and identities, particularly when Making activities are purposefully connected to familiar cultural practices that help students develop a sense of agency and authorship. In this sense, some studies advocate drawing from interdisciplinary practices to promote student engagement with STEM subjects via the conduit of Maker technologies to further encourage student intellectual risk-taking, experimentation, and iteration. Underscoring the need for such interventions is the recent work of Jennifer De Witt, Louise Archer and Julie Moote (2019) which found girls' disengagement with physics was in part caused by their 'socialised dispositions and internalisation of a cultural arbitrary through which they 'know' … they are 'not suited' to the study of physics, despite being aware of the 'strategic value of the subject' (p.1083).

The third subset of Maker Education studies in the scholarly literature focuses on using Maker technologies in schools to develop students' soft skills, sometimes referred to as 21st Century skills: creativity, innovation, communication, collaboration, and problem-solving (Peppler et al., 2015a, 2015b). This work is exemplified by Brahms' (2014) study of the 'soft-skill' social-learning affordances

of Maker technologies in school settings (Brahms, 2014) and a broader suite of projects which investigate how students engaging with Maker technologies experience a form of situated learning that encourages social interaction and collaboration through the requirement for novices to learn in active participation with more experienced others (Vossoughi & Bevan, 2014). In this regard, Halverson and Sheridan (2014) assert that the use of Maker technologies in schools offers a conceptually non-traditional productive space for students to engage with creative processes which, in turn, may foster innovation. Supporting this view are an increasing number of descriptive Maker Education studies focused on student engagement with Digital Fabrication, Programming and Physical Computing Maker technologies – either separately or in combination (Peppler, 2014, p.19). Examples include students using Digital Fabrication Maker technologies (3-D Scanners, 3-D Laser Cutters, and 3-D Printers) to produce or enrich tangible learning artefacts, and students using Physical Computing Maker technologies to create learning artefacts that they can wear or use, including LED Bracelets, cushions and wearable art with DIY switches or LED Origami, Greeting cards with DIY Switches and Pop-Up books (Graves & Graves, 2017).

Exemplifying the final reason for introducing Maker technologies to schools is the recent work of scholars concerned with the domination of Makerspaces by a certain demographic (i.e., white, middle-class, adult males). Here, studies conducted by Yasmin Kafai, Kristin Searle, Cristobal Martinez, and Bryan Braybrook's (2014c) 'Ethnocomputing with electronic textiles', and Kristin Searle and Yasmin Kafai's (2015a, 2015b) 'Culturally Responsive Making and Gendered and Indigenous Perspectives on Computing and Crafting' argue that students historically marginalized from traditional STEM educational systems have not had equal access to Makerspaces (TASCHA, 2012).

Sharing this view is Vossoughi and Bevan (2014) who problematize the notion that Making and Makerspaces are by nature democratising (as proponents of the 'Maker movement' have claimed) because the culture of Maker communities, Makerspaces, and Making programs, have been overwhelmingly dominated by the work, ideas, and images of middle-class white men. This view is shared by the recent work of Day Greenberg, Angela Calabrese Barton, Edna Tan and Louise Archer (2020) who use a 'complex lens of critical justice' to discern the 'dangerous territory' (p.476) of 'neoliberal entrepreneurialism' (p.478) in Maker Education regarding how its characteristics of 'individualism, economic competitiveness, and self-profit' (Greenberg et al., 2020, p.474) refuse to

'democratise the lives of those who engage with Maker education' and instead 'amplify systemic inequities' (p.476). In response, the authors advocate 'challenging inequitable power relations and normative structures' (p.506) by reconstituting Makerspaces in a manner that leverages collaborative innovations to serve the interests of the community, rather than individuals, thereby creating a 'richer and more socially consequential approach for the benefit of all' (p.506).

To redress the relative absence of girls and students from non-dominant cultural groups in Makerspaces, a number of Maker Education studies have sought to expand student interest and diversify student participation in STEM subjects and career pathways through the introduction of e-Textile Maker technologies (Kafai & Peppler, 2014). The foci of these studies include using e-Textiles to teach physical science (Peppler & Glosson, 2013) and/or build connections between home knowledge, STEM conceptual understandings and practices and institutional knowledge (Fields & Lee, 2016). Here the multi-disciplinary nature of e-Textile Maker technologies is understood to provide students with opportunities and a purpose for engaging in learning STEM content knowledge. For example, Peppler and Glosson (2013) found that youth (ages 7-12) creating projects with electronic textiles experienced significant gains in their ability to diagram a circuit while increasing their understanding of current flow, polarity, and connections. Such findings are reiterated by studies which found that the physical production of such projects allows learners to 'literally see the connections between physical actions, visual patterns, and relevant theories from physics, electrical engineering, and computing' (Buechley et al., 2013, p.152).

This desire to leverage Maker technologies to encourage girls and students from non-dominant cultural groups to engage with abstract STEM concepts and theories has led to some Maker Education scholars developing e-textile Maker technology designs to specifically support youth in learning STEM knowledge, concepts, and practices using eTextile Maker technologies (Kafai et al., 2014a; 2014b), whilst others have undertaken studies of Native American Indian students' engaging with craft practices (Searle & Kafai, 2015a) to show how e-Textile Maker technologies can be used to connect students to STEM learning through their traditional and heritage craft practices (Kafai & Peppler; 2011; Margolis et al., 2008).

1.4 What are the recognised barriers associated with using Maker technologies in schools?

Finally, this chapter examines the smaller – but important – literature relating to the barriers that are described in the existing literature as challenging the successful implementation of Maker technologies in school settings. This growing body of research in schools – which can be categorised as predominantly acritical and procedural in its outlook - indicates that school settings vary not only in terms of Maker technology offerings, spaces, and scheduling but also in the type and scale of challenges caused by the introduction, implementation, and management of Maker technologies in formal school settings.

Barriers associated with funding

In the first instance, the type, number and quality of Maker technologies and associated tools found in schools is most often attributed to ongoing funding challenges and competing educational programming priorities (Baldwin, 2013; Hsu et al., 2017). For example, a well-funded design-focused Makerspace may incorporate 3-D Digital Printers and 3-D Laser Cutters or a large assortment of power tools, robotics, various Physical Computing Maker technologies and Programming Maker technologies. Alternatively, some studies suggest that a lack of funding may limit schools to offering low-tech options such as paper circuitry or E-textiles and wearables. That said, researchers such as Blikstein (2008) counter that many resources needed in a school Makerspace can also be obtained simply through a computer with an Internet connection. This is exemplified by Blikstein's (2008) work with impoverished students in Brazil who used discarded electronics parts to create a variety of electronics and robotics projects. Further examples of school's using low-budget Maker technologies include engaging students in game design programs such as *SCRATCH,* graphic design software such as *Gimp,* and three-dimensional architectural design applications like *SketchUp* which offer opportunities for students to create digital artefacts that manifest constructivist learning principles.

Barriers associated with timetabling

Relatedly, many Maker Education studies argue that fundamental to enabling the development and conducting of appropriate assessments for students engaging with Maker technologies is the capacity for schools to overcome operational challenges specific to scheduling to ensure sufficient time to

enable equitable student access to learning (and assessment) opportunities with Maker technologies in K-12 school settings (Plemmons, 2014). This means schools operating within the confines of already crowded curricula – with or without other budgetary constraints - often offer students opportunities to engage with Maker technology learning activities only as short-term (mornings, afternoons, whole days or weeks) add-on stand-alone sessions (Bekker et al., 2015; Chu et al., 2015; Fitton et al., 2015) or in the limited form of single or double weekly elective lessons held over the course of a term or semester (Burke & Kafai, 2012; Esper et al., 2014; Fields et al., 2015). Moreover, when timetabling student access to Maker technology learning experiences during the school day is not possible, some schools meet the challenge of scheduling by promoting lunchtime or before or after school Making clubs (Denner et al., 2012; Schwartz et al., 2015) or holiday camps (Burge et al., 2013; Wagner et al., 2013; Franklin et al., 2013).

Barriers associated with school spaces

A further challenge reported in the Maker Education literature highlights how the physical setup of school Makerspaces can surface a variety of tensions in school settings. Once again linked to funding and budget allocations, some schools opt for a mobile Makerspace, often housed on a cart, which can be utilised by different departments around the school, whilst others may operate from a dedicated area. An alternative to this cart solution is the evolution of library spaces into a 'learning commons' that contains a dedicated Makerspace complete with trained librarians that can supervise and facilitate student access to Maker technologies (Plemmons, 2014), teachers bringing Maker technologies, tools, and materials to students each lesson or schools fitting out individual generalist classrooms with Maker technologies, tools, and materials. For those schools who are able to operationalise dedicated Making classroom spaces, the challenge of how to increase the efficiency of the physical environment emerges; that is, how to make it easier for students to move from one activity to another; spend less time in setting-up equipment or materials, speed up the process of clean up and storage, and therefore facilitate students spending more time Making and learning from the moment they arrive, until the moment they leave the Maker technology learning space (Madariaga, 2015).

Barriers associated with assessment-fit

Also related to the funding of Maker technologies in school settings is the challenge of assessment and accountability. This tension arises from the way classes delivering standard curricula use grades and/or marks to justify their funding of timetabled space and rooms, whereas Maker Education classes use students' consequential interest in picking up STEM subjects as their success metric and justification for funded timetabled space (Yaddof, 2016). Moreover, for many proponents of Maker technologies in schools, there is an incompatibility of Maker technology use in schools with regard to assessment and accountability because Maker technologies do not lend themselves to a strict curriculum or standardised assessment and reporting protocols (Halverson et al., 2014; Sheridan et al., 2014). Seeking a way forward to mediate this challenge, Brennan, and Resnick (2012), Briggs and Makice (2011) and Wing (2008) argue for teachers to develop new formative and summative assessment rubrics that assess for learning outcomes that demonstrate technological fluency (dynamic use of technologies to yield powerful products) and computational thinking skills (seeing the computer science principles imbued within their work).

This challenge of developing formative and summative assessments to use with students engaging with Maker technologies in schools is also highlighted by Brennan and Resnick's (2012) study of three types of assessment to measure and assess the development of student computational thinking skills (portfolios, artefact-based interviews, and design-scenarios). Here the researchers found their portfolio-based assessment was limited in scope because it assessed only each student's final products rather than measuring the extent to which student computational thinking improved. Brennan and Resnick's (2012) second form of assessment - artefact-based interviews – offered the researchers insightful data yet was considered too time-consuming as an evaluation tool for educators with large numbers of students. Design-scenarios were a third method of assessment used by Brennan and Resnick (2012). In this example, students were asked to explain a pre-made *SCRATCH* project, extend it, fix a bug, then add a new feature. Again, the researchers found this form of assessment was limited in scope and not scalable to diverse Makerspaces. In sum, Brennan and Resnick (2012) found that none of their assessment pieces adequately evaluated the extent to which students developed computational thinking skills as a consequence of engaging with Maker technologies.

Barriers associated with pedagogy-fit

Sitting alongside these funding, assessment, and operational challenges sits a range of behavioural and pedagogical challenges that often arise from teacher expectations that students will embrace not only productive failures as an essential attribute of their learning experience with Maker technologies but also may voluntarily assume the role of teacher rather than student when operating within school Makerspaces (Sheridan et al., 2014). This means that beyond being a physical resource for their students, teachers may also be required to 'adopt a relaxed sense of control' (Eisenberg & Buechley, 2008, p.65) and be comfortable with the unpredictability that may arise when using Maker technologies in their classroom setting. This is in addition to the requirement for teachers to create Maker technology learning spaces that are minus teacher-centred curriculum, yet rich with resources that enable productive and impactful work (Jenkins et al., 2006). Each of these expectations cumulatively gives rise to a fundamental tension that is underscored by the work of Peppler and Bender (2013) who argue that teachers using Maker technologies in Making classrooms should act as 'trained facilitators' who have the knowledge, skills and confidence to model and scaffold specific processes to assist independent student use of a range of Maker technologies (Peppler and Bender, 2013, pp.23-24).

Sean Justice's (2016) single case-study of teacher responses to using Maker technologies in schools concurs with these views. Premised on a desire to understand the extent to which teaching changes as a consequence of learning to use digital technologies in their practice, Justice (2016) illuminates specific Making and learning practices from a teacher's point of view by creating what he calls a 'Ways and Challenges' (p.8) typology to map teacher practices in relation to digital Making and learning at a granular level. Here the author argues that one of the main benefits of his typology is the way it can be used to hold complex encounters with materiality open and in relationship (p.11) wherein teachers' challenges are understood as enacted encounters of digital materiality, and digital tools as entangled with materials and spaces (p.14).

Theoretically describing this as an example of a 'co-emergent unfolding assemblage of knowing as material learning' (p.15), Justice (2016) advocates for schools to loosen their grip on what goes on in classrooms and instead build a culture where students and teachers can work in partnership that

renders each ‘open to co-emergent participatory enacted encounters, when practice responded to the ebb and flow of collaborative agency’ (p.15). Here Justice (2016) further poetically describes observing innovations and insights emerging in his preferred model classrooms as students and teachers ‘weaving their voices to those of the tools and materials on offer’ so their ‘practice became present as a material in itself, and staff as artful colearners’ (p.15).

More specific to the challenges confronting teachers, Justice (2016) proposes schools revisit their taken-for-granted relational configurations of teachers, learners, learning spaces, digital Maker technologies, materials and tools that purportedly hold great promise if teachers have the confidence to embrace a materiality of practice, rather than locking themselves into following systemic (and prescriptive) linear pedagogical approaches. Accordingly, Justice draws four significant conclusions about teaching practices associated with Making technologies from his Maker Education study, with each requiring teachers to understand:

(1) teaching practices evolve and emerge as a ‘dynamic fluttering, a wobbling between traditional practices, Maker ecologies and learning ecologies’.
(2) teachers ‘losing a little control suggests a gain of traction’ (p.15).
(3) teaching practices do not centre on the figure of the teacher, thus require a different kind of language to describe the complexities that digital Making and learning pedagogies.
(4) learning with Maker technologies requires students to spend more time in the space between objective and product in accordance with their own needs, which may alter what ‘learning’ means for students and teachers alike (p.16).

Barriers associated with teacher preparedness

These increasing demands on teachers make manifest the last and most urgent challenge cited in the much of the emergent research literature with regard to schools implementing Maker technologies i.e., the need for schools to provide focused professional support and training for teachers. Exemplifying the urgency of this need is Daugherty and Custer’s (2012) study of professional development offered to secondary engineering teachers which found a suite of teacher concerns about teaching with Maker technologies. These include teachers feeling there is a lack of resources, perceptions of teachers being considered as low importance by school leaders, anxiety amongst teachers with regards to comfort level in using digital fabrication Maker technologies, and a general

lack of motivation of teachers to participate in professional development attributed to the preceding factors. Such findings are mirrored by Nadelson et al. (2012) who argue for a deeper examination of the comfort, inquiry, and pedagogical discontentment of teachers using Maker technologies in school settings; particularly for teachers of STEM.

To address this last challenge, Martinez and Stager (2013) suggest teachers undertake hands-on training to develop a basic understanding of the design principles, physical properties of materials, and workflow strategies needed to facilitate the integration of Digital Fabrication, Physical Computing, and Programming Maker technologies in school settings. Likewise, Koh and Abbas (2015) argue for teachers working in school Makerspaces to receive strong technology integration training in a manner that additionally addresses the capacity for teachers to teach students engaged with Maker technologies about why a particular technology is appropriate to achieve a desired learning outcome. Pragmatically offering a potential solution to this sense of teacher discomfort with using Maker technologies is the pilot study conducted by the University of Nevada which employed a mobile Makerspace professional development program to increase teacher confidence when using 3-D Printing and other new forms of technology (Purpur et al., 2016). Blikstein (2013) also forewarns such approaches are essential as without providing professional support for teachers, school Makerspaces run the risk of being little more than 'outposts' for simple media products, crafts, and digital fabrications that are devoid of meaningful STEM applications or deep personal significance (Blikstein, 2013).

1.5 Where is gender in recent Maker Education studies?

Interest in increasing the number of girls engaging in STEM subjects and career pathways has been a focus of 'gender equality' policy since the mid-1980s. In the Maker Education STEM subfield, government sponsorship of Maker Education in schools to achieve this goal spans almost a decade. Yet curiously to date, no studies have been found applying a feminist perspective of gender to help us understand girls' engagement with Maker technologies in schools. This absence is noteworthy in Papavlasopoulou et al.'s (2017) review of 43 Maker Education studies (2011-2015), Schad and Jones' (2020) systematic review of 20 Maker Education studies (2014-2018) and discerned by the present study's examination of five recently published Maker Education studies (2019-2020).

For example, no mention of feminist perspectives on gender is made in Dalton's (2020) study of

integrating language arts classrooms with Makerspaces, Hung and Lin's (2019) exploration of Maker Education's social-design-based curriculum, Maia's (2019) ethnographic study on how to integrate the processes and practices of the broader Maker Education initiatives into school settings nor in Kajammaa et al.'s (2020) investigation of the demands Makerspaces pose for balancing teacher-student interactions, particularly in terms of teacher interventions and students' collaborative work.

Rather, when gender is mentioned in Maker Education scholarship writ large, binary categorical understandings of gender dominate wherein the term gender repeatedly appears as a politically neutral category of analysis or description of sex. For instance, Jones' (2020) exploration of teachers' perceptions of a Maker-centred professional development experiences uses gender as an umbrella category to describe the demographic data of staff (p.8) and then as an adjective when outlining his 'Elemental' and 'Descriptive' coding label, 'Gender considerations'; Nichols' (2020) uses gender as an adjective as he describes 'gendered expectations', 'gendered inequality' and 'gendering unpaid labour' and; (3) Godhe et al.'s (2019) exploration of the tensions associated with bringing Maker technologies into K-12 schools refers to gender once, also as an adjective, when warning that unsupervised students engaging in Maker learning practices risk reproducing 'gendered hierarchies of intelligence'. Noteworthy here, however, is that Godhe et al. (2019) do encourage future researcher consideration of the social, cultural, and political contexts of Maker Education by asking questions about the politics of Maker technologies; a challenge accepted - and enacted by the present study's focus on the politics of gender.

1.6 Summing up and looking forward

This chapter has provided an initial overview of the existing academic literature around the broad topic of Maker technologies and education. In doing so, it has identified several salient issues which can be taken forward into this study's subsequent discussions. On one hand, the disparate nature of the topic 'Maker Education' certainly encompasses a variety of technologies, practices, and motivations. On the other, this introductory chapter has developed a conceptual basis from which to organise the present study's subsequent discussions. In particular, it will be useful to draw upon existing frameworks to clarify the types of Maker technologies used in Greenfield College, and the perceptions of benefits and barriers which are thought to challenge the use of Maker technologies in the school, particularly for girls.

Further, this review illustrates that although there is a smattering of studies that have sought to theoretically engage with the use of Maker technologies in schools, most Maker Education scholarship is instrumental and technologically deterministic in nature, mostly offering descriptions of Maker technology use in classrooms or clubs, practices, and/or the motivations and barriers to their successful implementation. Moreover, although there has been some focus on how to use a more diverse range of Maker technologies and inclusive pedagogical practices to engage girls in STEM, to date there has been a feminist theory 'blind spot' (Heybach & Pickup, 2017, p.614) in Maker Education scholarship which has implicitly – and problematically - rendered gender apolitical.

Chapter 2. Digital technologies and schools as institutions

Whilst Chapter 1's examination of emergent Maker Education scholarship provides a useful basis for this thesis; it also reflects the emergent field's limited theoretical scope. Thus, to assist the present study's efforts to develop - and apply - a more rigorous and rounded theoretical perspective on the issues discerned in Chapter 1, this second chapter provides a survey of literature on schools and technology in Educational Technology scholarship over the past three decades. Commencing in the 1980s-1990s with studies focused on stand-alone computing, then the 2000s where scholars explored the use of networked computing in schools, followed by scholarship from the 2010s that has focused on the broader social media milieu of digital technologies, it is evident that most scholarly interest in recent years has been drawn to the Higher Education context, and the areas of teaching and learning. Moreover, of the few educational technology studies that have explored K-12 schools, scant attention has been paid to either schools as institutions and/or the social structures of schooling, with none particularly focused on gender, and most theoretically vague.

2.1 Schools and computer technologies (1980s -1990s)

Focused on stand-alone computing, early studies of schools and technology in the 1980s and 1990s cast doubt on the notion that bringing technologies into schools would be enough to deliver a more democratic, equitable form of education.

Larry Cuban (1986) – Computer meets classroom, classroom wins

The seminal work of Larry Cuban (1986) contends that educational technologies in schools have a long record of delivering broken promises 'in academic achievement, creative classroom integration of technologies, and transformations in teaching and learning' (Cuban, 2001, p.189). In his 1986 historic review of *Teachers and Machines: The Classroom Use of Technology since 1920,* Cuban (1986) explains this circumspect assessment by arguing that each effort to implement a 'new' technology in a school has been historically accompanied by the desire of managers and administrators to increase productivity and efficiency. Further, Cuban (1986) notes that each managerial push for teachers to use a 'new' technology in their classrooms – from chalk, slate, books, pictures, lantern slides, travelling school museums to radio, film, language laboratories, programmed learning machines, computer assisted instruction and the use of typewriters – has rarely invited teachers to participate in the top tier organisational decision-Making process or plans for the said technology's implementation.

Cuban (1986) thereafter argues that it is the presence of powerful institutional forces in schools and education systems more generally that prohibit the successful implementation of new technologies in schools. Pointing to the way each 'new' educational technology 'promoted as revolutionising instruction … seldom appear[s] in most classrooms today' (p.54), Cuban (1986) subsequently makes the point that those 'new' technologies which have endured - books, overhead projectors, and white-boards - have done so because they are compatible with the daily 'situational constraints' imposed on teachers by institutional forces. These include requirements for teachers to 'face 30 or more students in a classroom for a set period' and the need to 'maintain order and inspire the class to learn content and skills mandated by the community' (p.81). Cuban (1986) concludes by arguing that the failure of teachers to deliver the 'promise' of computing technologies is stymied by teachers dealing with pressures to balance the internal pressures of internal institutional arrangements, managerial expectations, and internal accountability measures. In so arguing, Cuban (1986) further suggests that this lived reality inside schools ensures that teachers will only adopt new technologies when convinced that new technologies will deliver the productivity and efficiency objectives of classroom discipline, engagement and achievement proscribed by those occupying the top tiers of school organisations.

David Tyack and William Tobin (1994) – The Grammar of Schooling

Also picking up on the idea that school organisations institutionalise their values through socio-cultural structures and organisational practices is David Tyack and William Tobin's (1994) *The "Grammar" of Schooling: Why Has It Been So Hard to Change?* Here, the authors draw from political and institutional theories to inform their attempt to explain why educational reforms work in some schools but not for others. Using historic case studies of unsuccessful educational reform efforts in the United States, Tyack and Tobin (1994) argue that the principles guiding schools - the 'grammar of schooling' - which they define as 'the regular structures and rules that organise the work of instruction [including] standardized organizational practices in dividing time and space, classifying subjects and allocating them to classrooms, and splintering knowledge into 'subjects'' (p.454), have persistently frustrated efforts to implement educational change in schools for more than a century.

Tyack and Tobin (1994) outline three main approaches scholars have applied to better 'understand the persistence or transiency of institutional frameworks that shape instruction' (p.466) in schools. These include: first, a political approach that examines contested social locations in schools and the relative power of groups that press for change or stability; second, a functionalist approach that

largely discounts notions of contestation and instead focuses on organisational stability and how change occurs in a relatively stable manner over time to meet the institutional needs of schools; and last, a cultural construction of schooling approach which argues that the purposeful construction of a 'congruence between cultural beliefs and organisational forms' through institutionalising structures, practices, processes and protocols legitimates cultural perceptions of what constitutes a 'real school' and therefore legitimate educational experiences. Accordingly, the assertion is made that understanding schools culturally as 'institutionalised organisations' does much to explain why very different kinds of communities operate similar institutional forms in schools (Tyack & Tobin, 1994, p.466).

Also informing Tyack and Tobin's (1994) subsequent discussion is the view that schools are essentially political in nature yet much of the educational practice that occurs in a school's 'political arena' has thus far been taken for granted and treated as politically neutral. Like Cuban (1986) and Hodas (1993), Tyack and Tobin (1994) make the claim that 'organisational structures in schools shape the conditions under which teachers engage in the 'batch processing' of students'; particularly through enforcing expectations that teachers will 'monitor and control students, assign tasks to them, and ensure that they accomplish them' and use 'teacher centred and textbook centred practices' (p.455).

Building on Cuban's (1984) finding that there are 'striking regularities over time in how teachers taught within these institutional arrangements' (Tyack & Tobin,1994, p.455), the authors reiterate their view that schools are best understood as political organisations that socially and culturally institutionalise a range of processes, protocols and instructional practices to meet the needs of 'particular groups with particular interests and values at particular times' (Tyack & Tobin, 1994, p.476). This leads Tyack and Tobin (1994) to argue that although 'cultural constructions of schooling have changed over time and can change again' (p.478), meaningful change in school can only occur if a widespread commitment 'to a new sense of the common good' (p.479) is made in public discourse about education. Moreover, to avoid the 'rich paper trail of reforms in the advocacy stage, when people make ambitious calls for them but when they fade, silence ensures' (p.455), the authors more specifically argue that 'intense and continual public dialogue about the ends and means of schooling' and 'questioning what is taken for granted but also preserving what is valuable in existing practice' is needed to disrupt then reconstruct the cultural assumptions that underpin shared beliefs about what constitutes 'a "real school" [and] what sort of improved schooling could realize new aspirations' (p.478).

Stephen Hodas (1993) – Technology and the organisational culture of schools

Stephen Hodas (1993) also determined that technologies used in schools are not value-free but are rather used to support 'highly normative, value-laden institutional and social systems' (Hodas, 1993, p.15). Describing schools as 'actors and venues for the performance of significant shifts in social mores and policy' (Hodas, 1993, p.3) and technologies 'embed[ding] their norms and processes in their outputs' (p.17), Hodas (1993) goes on to suggest that the failure to 'alter the look-and feel of schools' through the implementation of new technologies 'results from a mismatch between the values of school organization and those embedded within the contested technology' (Hodas, 1993, p.1). Hodas (1993) justifies this view by suggesting that irrespective of spatiality, schools in the 1990s continued to approach the task of implementing new technologies in the same manner used for more than one hundred years. This process includes: first, a proclamation is made of the 'potential of the new tools to rescue the classroom from the dark ages and usher in an age of efficiency and enlightenment'; second, school leaders discover little if any use is being made of the said technology; third, when a new technology is being used, the 'classroom practice - the look-and-feel of schools - remains fundamentally unchanged' and fourth; the blame for the 'implementation failure' of new technologies is largely attributed to the 'temperamental shortcoming[s]' of teachers (Hodas, 1993, pp.1-2).

Hodas (1993) refutes this simplistic explanation by instead arguing that a school's lack of success in adopting new technologies is better understood by exploring the social, cultural, and political attributes of the 'rationalist model(s) of the school-as factory' (p.12) and this model's objectification of classroom teachers as 'instructional delivery vehicle(s)' (p.8). From this standpoint, Hodas (1993) asserts that schools adopting this ethos deny the very possibility of innovation associated with the adoption of new technologies in schools because the school's ethos itself '(re)casts' education as a simple didactic process of transferring information from 'repository to a receptacle' which excludes the recognition (and role) of 'the rich, tumultuous, contradictory social processes that situate the student, the teacher, and the school within society' (p.8).

Further underscoring the incompatibility of 'factory models' of education to the prospect of innovation, is Hodas' (1993) additional point that the administrative and managerial use of computer-based technologies in schools is indelibly wed to values associated with standardisation, efficiency and efficacy in most all aspects of school life. For Hodas (1993), these values are made manifest through the way computer technologies are harnessed to track and monitor the progress and work

habits of students (p.12) and all aspects of teachers' work. Here Hodas (1993) again reiterates his thesis that technologies cannot be understood as 'value neutral' because their administrative and managerial purpose 'sends unambiguous signals about what school is for and what qualities teachers ought to emulate and model' (Hodas, 1993, p.12). In this regard, the author's further point that 'interpersonal and social dynamics, serendipity, cognitive apprenticeship, and play all seem to be disdained by this instantiation of machine learning' (Hodas, 1993, p.14) similarly resonates with the way everyday schooling policies, practices and processes today quickly stifle enthusiasm for using Maker technologies in schools to 'enrich' student learning.

Indeed, many of the ideas articulated by Hodas (1993) and his understanding of 'school organisations [as] hierarchical institutions' still hold currency for contemporary scholarship. Particularly useful here is Hodas' (1993) view that schools are 'organizations defined by their lines of flow of power, information and authority' (p.3) and that schools should be understood as an interplay of organisational elements and 'rational' and 'normative' (p.3) institutional elements. So too is the author's argument that the relative non(use) of technologies in schools is in large part due to the 'tight coupling between technology and values it operationalises' wherein technology is a 'dependent tool dedicated to the service of an external mandate' (p.7). That Hodas' (1993) work can usefully inform contemporary Educational Technology scholarship is affirmed by the work of Nemorin and Selwyn (2017) who describe the outcome of their ethnographic study as 'a reminder of the tendency for school technology to work in 'support of highly normative, value-laden institutional and social systems' (Hodas, 1996, p.213 as quoted in Nemorin & Selwyn, 2017, p.593).

Parlo Singh (1993) – The social construction of student learning with computers

Parlo Singh's (1993) critical exploration of how schools socially construct student learning experiences with computers inside Australian primary school classrooms was the first in the Educational Technology field to think about the gendered nature of computers. Through her systemic micro and macro analysis of the institutional dissemination of pedagogic discourse as classroom practice in a primary school context, Singh's (1993) study is widely held to be the first to apply social constructivist theory to show how power and control relations external to student classroom experiences manifest constructions and reconstructions of subjectivity inside the classrooms. By applying Bernstein's (1990) theory of pedagogic discourse to analyse the social construction of computing as an institutional discourse and practice, Singh's (1993) study found that 'control over the pedagogic device becomes the site of struggle and conflict between groups of students, teachers,

parents and administrators who attempt to incorporate their ways of knowing and interacting' and that 'consensus between conflicting interests may be realised through the construction of a hierarchy of discourses regulating classroom practice' (Singh, 1993, p.40). Particularly significant here is Singh's (1993) observation that 'by socially constructing educational discourse as scientifically neutral, rational, progressive and child-centred, the pedagogic device attempts to mask conflict' (p.40).

Moreover, Singh's (1993) application of theory to make sense of her classroom observations and interviews with students, teachers, software designers, computer consultants, local government administrators and inspectors is instructive. Surfacing the differential positioning of boys, girls and teachers with respect to the computer, their interactions with it and how related competences were socially constructed inside the classroom, Singh's (1993) integration of macro and micro levels of analyses shows that the social construction of male technological expertise and 'deficit' models of girls in the classroom was enacted by the repeated 'positioning of girls into powerless relations in the context of computer use' (Singh, 1993, p.56).

These findings are significant to the present study as they challenge the view that both teachers and female students deterministically 'naturalise' their classroom positioning. Further, although Singh's application of theory was unable to show how girls' internalised voices construct their own representation of the feminine' (Bernstein, 2000, p.120), it did optimistically argue that it is possible for female students and their teachers to (re)negotiate how the social relations of girls, boys and teachers are positioned by pedagogic practices inside the classroom (p.56).

Janet Ward-Schofield (1995) – The social context of using computers in secondary schools

Janet Ward Schofield (1995) also argues in *Computers and Classroom Culture* that the socio-cultural attributes of secondary schools shape the way new technologies are adopted and are – in turn - influenced by technology 'often in some unanticipated way' (p.5). For Schofield (1995), fundamental to a school 'realising the potential' of computer technology to improve education is an awareness that schools and classrooms are social organisations. This understanding informs Schofield's (1995) two-year ethnographic study of one American high school wherein she focuses on how the classroom use of computers impacts the social functioning of classrooms and how the social context in which computers are used impact student (non) usage experiences.

Asserted from the vantage point of direct classroom observations, Schofield (1995) challenges determinist notions that the use of computers in classrooms will, in and of themselves, increase social

interactions amongst students. This is made manifest by a range of factors Schofield (1995) observes which contradict 'the emerging consensus that computer use tends to increase peer interaction and to foster cooperative behaviour' (p.211). These factors include: the physical placement of classroom computers, the task structure imposed on students by the teacher, the financial and organisational factors that influence the number of computers purchased, the locations chosen for computer placement, and the nature of the software chosen for students to use. For Schofield, these factors (and others) 'work both singly and in combination to shape the way computer use influences peer interaction patterns' (Schofield, 1995, p.211) and student learning experiences with computer technologies more generally.

Regarding student experiences with computers, Schofield's (1995) study also found that student computer use can also negatively exacerbate at least two long-standing social problems. First, the divide between the 'haves' and 'have nots' (p.214) in the sense that academically advanced students in Schofield's (1995) study had more access to computers than their peers; and second, computer use patterns 'reflected and reinforced pre-existing gender differences' (p.216). Here, Schofield's (1995) discussion is reminiscent of Singh's (1993) descriptions of girls being constructed as technologically 'deficit' through and by their classroom experiences of computer technologies. This is exemplified by Schofield's (1995) suggestion that the social construction of 'the image of computing as a male domain' was reinforced by the way male students were given more access and more opportunities to acquire computing knowledge and experience whilst girls were 'routed toward relatively unremunerative secretarial and clerical jobs traditional for women' or endured 'factors which conspired to lead very few girls to enrol in the advanced computer science classes' or, experienced 'isolat[ion] from their peers, or […] behaviour[s] ranging from teasing to occasional outright sexual harassment' (pp.216-217).

In considering the question of whether computers can achieve their 'transformative potential' in schools, Schofield (1995) reiterates the view articulated by Cuban (1986), Hodas (1993), Singh (1993) and, Tyack and Tobin (1994) that 'computer use in and of itself does not guarantee major changes in either the goals, processes, or outcomes of education' (p.217). To validate her position, Schofield (1995) points to a range of systemic factors – from the classroom, school, and district levels - which she describes as working together to 'mute' the impact of computers on the educational system. Significant for Schofield (1995) here is the disconnect between classroom teachers, academic scholars, and external providers such as software developers. Describing teachers as too wedded to

'an incrementalistic view of the computer's potential for improving education'(p.218), Schofield (1995) asserts that a classroom teacher believes that the purpose of computers in schools is not to 'bring about fundamental transformative changes in the goals or methods currently typifying the educational system' but rather 'help teachers and students perform the work they already do more easily, efficiently, or effectively' [and] 'allow some already existing goal to be accomplished better than previously without creating offsetting, undesired changes'(pp.218-219). This echoes the views articulated by both Cuban (1986) and Hodas (1993).

Finally, Schofield (1995) also identified a range of socio-cultural obstacles that systematically explain the non(use) of computers in schools. These include barriers that are a 'function of classroom practices and culture' such as teachers being required to change the format and delivery of their lesson material, a lack of computers or technical support and teachers being confronted with the need to change their role (and identity) from instructor to facilitator. At the school and school district level, Schofield (1995) cites a lack of incentives for innovation, the expense of equipment and training to support teachers (p.221). Moreover, like Hodas (1993), Schofield (1995) also argues that the most significant barrier is the 'almost overwhelming importance attached to student performance on standardised testing regimes and the accompanying practice of measuring the value of educational innovations by their impact on such tests' (pp.221-222).

Instructive to this thesis is Schofield's (1995) empirical confirmation that the social complexity of Educational Technology requires researchers to investigate how individual broader social factors are knitted into a school's organisational framework. Two years later, Schofield's (1997) review of 'what we have learned to date about investigating the general question of the impact of computers on the social functioning of classrooms' (p.28) affirmed her earlier position that 'thinking of a computer use as a unitary independent variable with readily predictable effects is flawed' (p.27). This is because the perceived 'innovative' outcomes associated with the adoption of new technologies in schools – improved student motivations, peer interactions, and teacher pedagogical shifts away from didactic instruction to personalised learning – are 'dependent to a marked degree on the existing social milieu in classrooms and school districts' (p.35).

Mary Bryson and Suzanne De Castell (1998) – Schools, Gender (In)equity and Technology Innovation

Writing at a time when computer coordination and administration positions in elementary schools were dominated by men, Mary Bryson and Suzanne De Castell's (1998) exploration of how gender

in(equity) contributes to the (lack) of take up of computing by female staff begins by outlining the widespread acceptance by staff that 'gender equity and gender issues are non-issues in elementary schools' (p.556). Here the authors outline a series of differential explanations to explain the lessor interest of women in computing. These include that 'left-brained' versus 'right-brained' people (p.556) have different computing dispositions, males are more 'interested in computers and machines in general' and male 'computer coordinators deliberately withhol[d] their technological expertise' (p.557) from female staff.

A key finding of Bryson and De Castell (1998) is that although many staff hold 'very clearly gender-differentiated conceptions of male and female technological competence' (p.558), few staff were aware they held gendered assumptions or that they were partaking in gendered practices that influenced the development of female technological expertise. These assumptions included teacher views that 'all the boys seem to really like the computers, and not too many girls are really keen' (Bryson & De Castell, 1998, p.559), whilst gendered practices included male computer coordinators describing their gender-differentiated pedagogies when teaching technological skills:

> If I'm teaching a new application in the class that has mainly boys, I'll explain more the why and the reasons behind the program. If the class is mainly girls, I'll say, well, just do this and this and don't worry about why or how it works; don't worry about the logic behind it (Bryson & De Castell, 1998, p.558).

Further evidence gathered by Bryson and De Castell (1998) that was indicative of staff engaging in gender-based inequities and consolidating stereotypes included the designation of male teachers (and students) as computer experts irrespective of their actual level of skill, only male teachers participating in discourses 'ventriloquat[ing] computer jargon', male administrators and computer coordinators viewing female acquisition of technological competence as problematic, and students holding gendered beliefs about female technological competence that mirrored their teachers (pp.559-560).

Instructive to this thesis too is Bryson and De Castell's (1998) further finding that it was not until these gendered assumptions were empirically pointed that 'school personnel were able to acknowledge their gendered assumptions and practices with respect to technological expertise' and 'even then, most participants appeared unwilling to attempt to intervene directly to bring about more equitable conditions' (Bryson & De Castell, 1998, p.560).

2.2 Schools and networked computer technologies (2000s)

From the 2000s, scholars interested in the use of computer technologies in schools turned their attention to networked computer technologies that provided opportunities for schools to connect via the internet to an ever-expanding store of information and real-world authentic contexts.

Zhao and Frank (2003) – The Ecology of schooling

In their efforts to systematically explain the use of educational technologies in schools, Yong Zhao and Kenneth Frank (2003) constructed an open-system ecological perspective to 'capture the organic process of technology use in schools' (p.828). Here the authors regard all technology users within a school's 'ecosystem' as living species wherein teachers act as existing 'keystone species' (p.816) and educational technologies represent the 'invasion of an exotic species' (p.815). This dramatic portrayal of the way technology enters schools echoes the work of Cuban (1986) and Hodas (1993), whereby Zhao and Frank (2003) characterise the process of technology adoption in schools as a 'rich, complex process of coevolution' rather than a static 'laundry list' (p.810) of isolated correlating factors catalogued as enablers or blockers. Here, however, Zhao and Frank (2003) argue that their ecological metaphor represents a significant methodological departure from research methods advocating the examination of specific variables in isolation.

Articulating three characteristics associated with technology innovation – longevity, fecundity and cope fidelity - Zhao and Frank (2003) suggest their analytical frame can be applied across multiple contexts: (1) longevity - this characteristic relates to how long the innovation can be supported at multiple levels of the school ecosystem; (2) fecundity - this characteristic pertains to the ability of the innovation to propagate itself and therefore 'survive' an array of subfactors that will determine whether the innovation can be practiced and supported by a range of capital resources in different contexts; and (3) copy fidelity - this characteristic describes the degree to which the technology innovation affords new users the flexibility to adopt the values that drive the innovation whilst also changing some aspects of the innovation's form to suit local contexts and needs (Zhao & Frank, 2003).

According to Zhao and Frank (2003), crucial to the success of technological innovation is a complex understanding of the social, cultural, and political context in which teachers - and the proposed technological innovation - operate. Thus, by describing the school as the place where the 'teaching context' nests, Zhao and Frank (2003) add their voice to the chorus of already discussed Educational

Technology scholars who urge researchers to scrutinise more closely 'the multiple ecological hierarchy [of] government agencies, societal institutions, local community organizations, and the school bureaucracy' (p.815) *and* the external forces which enter the school ecosystem at the time the innovation is introduced. In this regard, Zhao and Frank (2003) particularly argue for researchers to examine external forces such as social and political institutions, new pedagogies, and how internal social structures and other pressures alter expectations of teachers and students (p.828).

Thus, useful to this study is Zhao and Frank's (2003) proposition that researchers focus on the material, discursive and symbolic contexts of schools, particularly 'how teachers relate to new technology in their ecosystem both as individual organisms and as members of a social system' (p.827). Also useful for the present study is Zhao and Frank's (2003) reminder for researchers to attune themselves to the ebb and flow of multiple factors, relationships, and individual, organisational, pedagogical, and technology-related variables rather than simply identifying and cataloguing each of these factors in isolation.

Torin Monahan (2001, 2005) – The politics of technologies in schools

Similarly urging researchers to focus on how technology design processes shape the educational possibilities of Educational Technology in schools after they have 'landed' (p.22) is Torin Monahan's (2001) study of *The Analog Divide: Technology Practices in Public Education.* Justifying his focus by stating this is a 'neglected area in studies of education and technology', Monahan's (2001) ethnographic study usefully advances a new 'technology practices framework' to help scholars, educators, policy writers and school leaders better understand why inequities persist in education despite abundant technology access for students (p.29).

From the outset, Monahan's (2001) work is underscored by a political undertone. Analogising the implementation of technologies in schools to a single-minded 'war on poor academic achievement' (p.22), Monahan (2001) extends his use of this military metaphor to describe how ill-supported school technology coordinators operationalise an 'elaborate manoeuvre of technology implementation' to quell 'discord in the ranks' and silence 'questions [over] the existence of any overarching strategy or purpose' (p.22). Here echoes of the concerns raised by Cuban (1986) and Hodas (1993) are heard as Monahan (2001) too bemoans the marginalisation of teachers in terms of their exclusion from decision making processes regarding how Educational Technology are brought into schools. Furthermore, like Cuban (1986) and Hodas (1993), Monahan (2001) also empathises

with teachers by contending that teachers may choose to sideline themselves from technology due to 'their own pedagogical uncertainty and territoriality [which] compel[s] them to resist' (p.23). Here Monahan (2001) suggests that teachers forced to use 'cluster style classrooms' in schools 'may feel discomfort' due to the way this pedagogical model defies the power relations underpinning their habituated institutionalised instructional models which 'all but demand disciplined bodies, centralised authority, and one-to-many information-transmission' (p.23).

Instructive to this study is Monahan's (2001) further assertion that his work 'offer[s] a corrective to analyses that put excessive faith in technological fixes to social problems' (p.30) and his subsequent call for future researchers to closely examine the design of technology practices and processes; particularly with regard to how these operate within the 'material, discursive, and symbolic contexts' of schools (p.22). Here, the 'material context' is comprised of technological artefacts (like, computers, books, and desks), spaces (such as classrooms), and infrastructures (such as school facilities and computer networks); 'discursive contexts' relate to individual relationships, school organisational communications and policy negotiations and; 'symbolic contexts' encompass the variance of cultural meanings and logics associated with the aforementioned artefacts, images, discourses, and processes (Monahan, 2001, p.2).

Monahan's (2001) subsequent application of his 'technology practices framework' to analyse the data gathered in his own ethnographic study also proves useful. Here, the author uses each contextual dimension to analyse his fieldwork descriptions of formal and informal student learning experiences, transcribed interviews and general conversations, excerpts from electronic postings, photographs, fieldnotes containing iterative descriptions of spaces, artefacts, and people along with their various interactions to give 'context and depth' to his analyses. Such qualities, Monahan (2001) argues, would be unavailable to him had he chosen to 'artificially focus attention upon a single point of experienced reality: technological artefacts' (p.29).

Also significant to the present study is Monahan's (2001) focus on making visible the power relations that constrain technological practices in school contexts. These include restrictions imposed on material designs of infrastructure that support some social activities whilst deterring others and constraints embedded within discursive and symbolic structures which communicate cultural values and assumptions associated with technology. In this regard, Monahan (2001) argues that although discursive and symbolic structures can greatly influence the technology design process and

associated practices, the meanings that students, teachers, and leaders interpret and negotiate through their interactions with material designs and technological artefacts, rituals, functions, words, and practices is 'often taken for granted and un-analysed' (Monahan, 2001, p.29). In this sense, Monahan's (2001) technology practices framework can be understood as an effort to 'shift the emphasis, and thus the conversation, away from topics that occlude difference, complexity and opportunities for meaningful change' (p.30).

Several years later, Monahan (2005) continued his exploration of the way many Educational Technology 'researchers eschew a substantive interrogation of materiality' by maintaining their instrumental, deterministic view of technologies as neutral artefacts. Here Monahan (2005) offers a counterpoint by instead asserting that educational technologies are better understood as 'political agents that shape lives and establish social orders' (p.99). Further, Monahan holds that investigating 'space, pedagogy, organization, policy, governance and imagination' (p.ix) holds the best opportunity to surface implicated power relations that are 'infused with values and ideologies of their creation' (p.x).

Writing in the 2000s, this significantly includes how neoliberal values manifest in schools through the simultaneous retreat of social programs at the same time state social control advances, and schools restructure, brand and market themselves as profitable corporations, accountability regimes inside schools proliferate in the form of tests, standards, benchmarks and audits, and schools shift to what Monahan (2005) calls a 'built pedagogy' which emphasises entrepreneurial training and apolitical acceptance of the status quo (p.2).

Accordingly, Monahan (2005) further argues that the state's substantial investment in educational technologies - purportedly to correct social inequalities through technology access - is instead better understood as a 'politically charged endeavour' (p.4). Thus Monahan (2005) argues for researchers to surface how the effects of globalization have become grounded in structural and symbolic relations of schooling by considering their 'situated specificity' (p.4) and 'particularity of each locality' (p.5) through investigating the multi-layered place narratives of individual schools.

Monahan's (2005) 'built pedagogy' approach is particularly useful to this present study because it urges a close examination of the context of technology use and the content of instruction to surface the politics of technological change in schools rather than undertake descriptive, instrumental studies whose focus on questions of efficacy obfuscate larger issues (and questions) of power.

2.3 Schools and digital technologies (2010 – 2020s)

In more recent years, the majority of studies published in the field of Educational Technology have continued their instrumental focus and applied examinations of individual digital technologies in schools – including mobile technologies, social media, one-to-one devices - thus providing descriptions of 'enabling' or 'blocking' factors without necessarily considering the social or political context of the school or schooling.

Yet over the past decade, there has also emerged a smaller but growing number of Educational Technology studies proposing a more nuanced, more socially contextualised view of digital technology use in schools and change. Notable here is that many of these studies affirm Hodas' (1993) view that 'schools' are places that operate as complex social systems made up of a large number of dynamically networked components, interactions and relationships that work together to 'preserv[e] and transmit information and authority, legitimating [some] sets of values over others through practices' (p.3). In other words, confirmed is the notion that schools are inherently political places. A selection of some of these more recent Educational Technology studies now follows.

Thomas Philip and Antero Garcia (2015) – Mobile technologies in schools

Situating their findings about students' experiences with mobile phones in the classroom within the broader political context of school reform (p.696), Thomas Philip and Antero Garcia (2015) interrogate the too often unquestioned assertions, claims and assumptions about the 'proximal' and 'distal' benefits of mobile technology use in schools which 'often drive important decisions regarding the use of technology in classrooms and thus obscure deeper questions about learning, interest, power, equity, and justice' (p.678). Here, the authors warn educators and scholars to be wary of 'novelty effect' (p.680) and 'quick fix' (p.696) descriptions of technology use in schools which 'institute market-oriented solutions in public education' (p.696), divert consideration of 'improving instruction, constructing positive school cultures,' (p.696) and overlook the role of the teacher and 'pedagogy, the learning environment, and the specific contextual affordances of the device [that] are indispensable' (p.680).

Calling instead for a closer examination of the contextual, social, and relational nature of technology use in schools, Philip and Garcia (2015) argue that rather than 'haphazardly' integrating mobile digital technologies in schools, educators need to better understand the 'hurdles' (p.695) and 'institutional challenges that exist' (p.698) prior to implementation. These obstacles include considerations of the

degree of freedom students will be afforded in controlling and directing their own learning, how classroom spaces and contemporary pedagogical models will be changed to support student learning and - more significantly - how reforms will address the host of 'historical, systemic, institutional, and individual factors' which schools must negotiate when working with 'poor and working-class youth of colour' (p.698). Thus, by expressing their concerns that schools are making significant decisions about incorporating technologies in classrooms without fully testing the highly ideological assumptions about technology's potential, Philip and Garcia (2015) additionally encourage educators and researchers to consider the situated context of technology use more critically in schools. Here the authors advocate asking the 'more pointed and difficult questions about the theoretical and empirical bases, in terms of learning and social, political, and economic power, for the use of innovative technologies in advancing the learning opportunities for youth of colour' (p.698) and providing teachers with the time and space to develop their professional knowledge and judgment about how to critically and creatively incorporate new technologies into their repertoire of classroom resources in contextually meaningful ways. Philip and Garcia (2015) additionally go on to argue that not questioning untested assumptions about the 'technological tomorrow' could otherwise undermine the 'democratic purposes of schooling' (p.702).

Craig Peck et al. (2016) – School reform and educational technologies

Craig Peck, Carol Mullen, Carl Lashley, John Eldrige and Ty-ron Douglas's (2016) exploratory qualitative study of the 'fitful progress toward a technology fuelled revolution in instruction' at two American high schools found that technology functioned both as an 'imperfect school reform effort that produced only partial instructional change and as a successful though uninvited disruptive innovation that allowed students to challenge and unsettle existing educational norms' (p.1). Prefacing their study by referring to the critical and empirical work of early and contemporary Educational Technology scholars, Peck et al. (2016) argue that their contemporary study augments established literatures as it also found that when it comes to educational technology use in schools, entrenched teacher-centred educational practices were a 'consistent norm rather than an occasional aberration' (p.14) even though many teachers were 'infus[ing] technology into their lessons with some regularity' (p.13). In this sense, the Peck et al.'s (2016) study work confirms early Educational Technology scholarship which suggested that introducing technology into schools is 'an example of imperfect school reform' (p.21). Here a range of divergent factors are once again identified, including infrastructure challenges, teachers not being involved in implementation planning and time-poor

teachers reactively adopting technologies in their classroom only if they suited or could be adapted to existing instructional and professional needs. Peck et al.'s (2016) study therefore confirms as still relevant Cuban's (1995) warning that 'reforms that are conceived and executed in a top-down manner by system outsiders and that do not include school constituents in planning and design have difficulty gaining traction and persisting' (p.22).

Isling Poromaa (2017) – Sociomaterial practices in schools and educational technologies

Isling Poromaa's (2017) socio-materialist views of educational technology use in schools offers a more theoretically nuanced study, as for the first time Poromaa (2017) weaves through more sophisticated strands of social theory in her analyses. Addressing the 'shortage of studies preoccupied with material factors and their influence over beliefs and actions in school practices' (p.385) in Educational Technology scholarship, Poromaa's (2017) sociomaterial perspective proposes scholars pay greater attention to the centrality of history to better understand school institutions as products of historic 'physical spaces' which arrange a specific organisation and distribution of properties and individuals in accordance with a particular position in social space (p.387).

In this sense, Poromaa (2017) considers that 'school buildings are not numb, dead places, but rather historical and present entities assorted with various resources that transcend the individuals who pass through the premises [by] shap[ing] practices of humans in relation to what they offer to individuals and social groups inside their walls' (Poromaa, 2017, p.387). Here Poromaa (2017) further asserts that power is made manifest through a school location, its buildings and the tangible objects contained within. As such, because each of the aforementioned frames the social practices enacted in a school - including the scope of internal and external social practices (Poromaa, 2017, p.386) - researchers should more closely attend to the school environment not only for its sociomaterial practices, but also to better understand how the internal school environment is a product of seemingly neutral, objective social interactions which may either consciously or unconsciously exercise power over the arrangement of resources, interior designs, and artefacts (p.387). For this reason, Poromaa (2017) argues for researchers to closely examine how a school's-built infrastructures and classrooms, classroom materials and more work together to influence teacher and learner experiences with educational technologies and refuse the notion that space and the identities of the occupiers within these spaces are fixed, or a given, but rather consider how all aspects are held in a constantly changing state of relational becoming (Poromaa, 2017).

Craig Peck et al. (2016) – The interplay of students, technology, education and change

Craig Peck et al.'s (2016) study of how the presence and use of personal technologies in two case-study schools supports 'the idea that a nascent transformation in student learning may be simmering' (p.24) due to 'changing norms at the two schools' (p.23). Citing instances of the use of online coursework as a mechanism - albeit in its infant stage - to engage and remediate students at academic risk, and students using technologies to disrupt classroom learning in unintended manners that compelled teachers to change their instructional practices, Peck et al. (2016) conclude that the implementation of new digital technologies in schools 'both competes and coexists with existing educational norms at the same time that it disturbs and reinforces traditional instructional practices' (p.24).

Here the implications offered by the authors' study are helpful to framing the present study's empirical inquiry in a number of ways: first, educators should investigate how and why traditional practices, including worksheets, quizzes, and tests, continue to hold such sway in high schools; second, educators should investigate whether technologies are being used to help transform classroom practices toward student-centred learning or replicate - rather than challenge - long-established paradigms of teacher-centred pedagogies and curricular control; third, researchers should discern the extent to which educators are aware that technologies can be part of - not the entire solution itself - a multifaceted solution to improve student academic achievement; and fourth, though 'relatively uncommon on educational technology research' (p.26), researchers should consider 'intensive site-based inquiry' as it provides 'valuable 'real world' insight into the dynamic intersection of technology, education and change (Peck et al., 2016, p.26).

Christo Sim (2017) – Disruptive fixation of digital technologies in schools

Christo Sims's (2017) spatial analysis of a 'cutting edge' reformist school set up to 'democratise education' through technology also considers how broader social, cultural, political, and material constraints powerfully find their expression in school structures, processes, and practices. Here Sims (2017) frames his ethnographic case-study using the notion of 'disruptive fixation,' a contingent yet recurring cycle of idealism that 'paradoxically helps lock social processes into enduring and regressive forms while also, and ironically, renewing faith in the promise of more rounds of cutting-edge interventions' (Sims, 2017, p. 11). Significant to the present study is the way Sims (2017) exposes how the uncritical use of terms such as 'community' and 'participation' in a school's ethos can consolidate conscious and unconscious biases and therefore limit education reform agendas. Further, schools

disavowing purposeful attention (and engagement) focused on social, cultural, political, and material constraints can lead to - at a systemic level - the replication and consolidation of values associated with traditional schooling systems. For example, efforts to enact a so-called progressive 'student centred' curriculum is restrained by the requirement to deliver a national curriculum to retain funding makes no provision for student input; hierarchical assessment scales are maintained albeit with labels replacing letters; and 'clock time - a mainstay of conventional schools, is reinforced through gamification' (p.92). Yet much like Singh (1994) and Bartow (2014), Sims (2017) also appears optimistic when citing examples of 'sanctioned counter practices,' moments when collective 'deviations that are permitted and valued' (p.104) do temporarily 'disrupt education' in the manner originally intended by reformers.

Neil Selwyn et al. (2017) – The impact of technologies on teachers' everyday lives

Historically locating their study of how educational technologies are shaping the changing demands of teachers' work in both 'liberating *and* exploitative; democratizing *and* disempowering' ways (p.403 - emphasis in original), Neil Selwyn, Selena Nemorin and Nicola Johnson (2017) propose that teachers' work with digital technologies in two Australian secondary schools constitutes a need for teachers to constantly negotiate their 'labour of teaching' with the demands of increased regulation, performance and accountability measures as part of their 'working conditions, occupational cultures, employment relations and worker organization' (p.390). Here Selwyn et al. (2017) explore the parallel incorporation of educational digital technologies at a time when the role of the teacher has expanded and 'intensified' (p.397) to include an array of 'immaterial' labour expectations such as the production of 'learning', 'skills', 'literacies', 'knowledge and less tangible forms of 'emotional labour' associated with student wellbeing.

Challenging presumptions that educational technologies always make teachers' lives easier, Selwyn et al. (2017) scrutinise the 'conditions, constraints and opportunities' afforded to teachers' technology-based work (p.392) by framing its use within the broader social, political and economic infrastructures of 'school' and 'schooling'. Here the authors argue that rather than transforming teachers' work and 'labour', digital technologies can instead perpetuate - and amplify - already established 'informational, communicative and managerial practices' to deliver an expanding array of 'political imperatives [including] mandated testing, curriculum, measurement and general capability' (p.400). Thus, whilst the standardisation of teachers' activities and actions using educational technologies are welcomed by some teachers, the increased emphasis on meeting

managerial 'work' expectations of consistency, transparency and efficacy also induces a heightened sense of anxiety and fatigue in others (p.400); an emotion further exacerbated by the way digital technologies enabled the intrusion of 'work' into teachers' personal lives (p.402). For this reason, Selwyn et al. (2017) suggest that teachers reframe their engagement with digital technology to ensure their engagement becomes 'a site of collective responsibility' which favours 'equitable and socially just' use (p.403).

Pollock et al. (2018) – Deep equity in 'blended' classrooms

Mica Pollock, Susan Yonezawa, Hilary Gay and Lillia Rodriguez's (2018) exploration of the benefits of face-to-face teaching to underrepresented, low-income students engaging in blended computer-based coursework found that teachers played an essential role in supporting computer-based learning. Contributing to a larger conversation about equity and technology use in education, Pollock et al. (2018) build on established scholarly understandings of 'equity' as 'a commitment to ensure that every student receives what he or she needs to succeed' as they prepare to enter College. Here teachers seek to 'develop the full human talents of each student and all 'groups' by offering necessary opportunities and resources' to fully prepare low-income, first-generation students of colour who are otherwise too often denied that opportunity' (p.3).

To assist these social justice endeavours, Pollock et al. (2018) developed a taxonomy of seven in-person 'teacher roles' that students' named as essential teacher support mechanisms which consisted of three 'basic equity' teacher roles focused on helping students access online content (teacher as fixer/explainer, monitor of behaviour, highlighter of content) and four 'deep equity' teacher roles focused on responsively helping students comprehend subject matter (teacher as explainer of content, extender and applier of ideas, provider of feedback and assessment, caretaker of student wellbeing) (pp.12-13). Significant to each was the need for teachers to responsively draw from their face-to-face teacher experiences to personalise student learning to ensure equitable access and understanding of computer-based coursework.

Determined by students to be particularly important to facilitating each student's 'success' was not simply the face-to-face presence of teachers but also the tangible emotional and creative energies teachers invested in their students to ensure all received the 'basic equity' and 'deep equity' support required 'not just for students to pass a test to earn a credit, but also for students to succeed in later courses' (Pollock et al., 2019, p.34). For this reason, the authors conclude that to ensure equity in

education using educational technologies, educational institutions advocating the replacement of face-to-face classrooms with computer-based coursework should also consider decentring the role of the teacher and reversing the paradigm of computer coursework supporting face-to-face learning in a manner that enables teachers to provide the in-person personalised 'basic equity' and 'deep equity' support students require that educational technologies on their own cannot offer.

2.3 Gender and educational technologies

There is a persistent lack of interest in applying feminist perspectives in recent Educational Technology scholarship. Rather, this field of 'a-theoretical relatively data-blind techno-deterministic micro-level evangelism' (Jameson, 2019) continues to enrich our understanding of - and appreciation for - the complexity surrounding the constantly evolving suite of educational technology tools being used - or proposed for use - in schools. Illustrative here is the critical digital sociological work of Mark Andrejevic and Neil Selwyn (2020) which posits a range of socio-political challenges associated with the use of facial recognition technologies, and the growing number of socially grounded critical studies of applied artificial technologies (AI) in schools which warn educators to carefully consider the benefits, challenges and risks associated with AI, particularly with regard to its association with 'big data' (Berendt et al., 2020; Dixon-Roman et al., 2020; Perrotta & Selwyn, 2020).

Most other recently published Educational Technology studies remain steadfast in their focus on micro-level understandings of the purported efficacy, benefits or challenges associated with the use of educational technology tools in schools, with each engaging with long practised technocentric, instrumental research approaches. These include recent studies of: digital gaming (Parry et al., 2020; Bowden & Aarsland, 2020; Rowan, 2017), video production and digital story-telling Educational Technology (Lim & Toh, 2020; Snelson, 2018; Stornaiulo & Thomas, 2018), *Twitter* (Gleason, 2018), the use of *Youtube* by teachers (Fyfield et al., 2020) and students (Masanet et al., 2019), mobile technologies (Forsey, 2017; Pirhonen & Rousi, 2018), student 'selfies' (Jackson, 2019), and educational technologies used to enhance teacher instructional approaches, for example flipped classrooms (Voet & De Wever, 2017) and student 'data-wrangling' engagement with large, complex data sets (Kayn & Jiang, 2020).

Writing in 2018, Rebecca Eynon expressed her concerns over the absence of scholars applying feminist perspectives in the field of Educational Technology scholarship. Here the present study's close examination of recent studies (2016-2021) reveals that on the few occasions when gender is

mentioned in the Educational Technology literature, the term usually appears:

(1) as a synonym (sometimes interchangeably used) with sex or sexuality (male/female).
(2) to describe a set of participant attributes, included with race, culture, ethnicity, and age.
(3) as a demographic data category, often included with age, country of origin, grade/level, place of residence, position, prior qualifications, socio-economic status, and years of experience.
(4) as an explicitly named factor to explain educational outcomes, achievements, and success, appearing alongside other factors including disability, family form, geographic location, personality, physical appearance, religion, sexuality, and socio-economic status.
(5) as an adjective (gendered) to preface achievement, biases, discrimination, differences, divisions, educational pathways, emotions, exclusion, harassment, identities, inequalities, issues, messages, outcomes, patterns, performances, practices, predictions, prejudices, privileges, relations, trends, variances, social construction, success.
(6) as a descriptor for a fixed role, at home, work, or school.

Yet it would be wrong to suggest that there has been no recent attention to gender or feminist inspired Educational Technology scholarship. In 2017 Stephanie Fisher and Jennifer Jenson employed a post structural understanding of gender and power as fluid, produced through and within social relations, to critically explore how a feminist intervention can help girls and boys resist subordinating hegemonic discourses of gaming, thus empowering girls to create their own digital games and 'do things differently' (p.96). Drawing theoretical inspiration from bell hooks (1994) and Patricia Hills Collins (2009) - both of whom advocate the lens of intersectionality to dismantle structural oppression of race, gender, and class – Lauren Leigh Kelly (2018) applied a feminist intersectional understanding of gender in her study of Black female students' use of *Snapchat* and other digital media forms to resist injustice and oppression and raise racial awareness in the school community individually and collectively. Instructive to this thesis is the way both examples illustrate how the application of a dynamic, relational understanding of gender can create opportunities to implement empowering interventions.

2.4 Summing up and looking forward

This survey of Educational Technology scholarship focused on technology use in schools over the past three decades has revealed an expanding use of theoretical perspectives that have cumulatively advanced the notion that the use of computer and digital technologies in schools should not be

considered a politically neutral endeavour nor a ready solution to specific educational problems. Rather, the progressive inclusion of historic, social, material, and spatial theoretical perspectives by educational technology scholars has increasingly painted a complex picture of how the use of computer or digital technologies in schools is influenced and shaped by entanglements with school structures, school spaces and, for some, the politics of schooling, both inside and beyond the school gate. Each of these scholarly insights can be usefully applied to the present study.

However, this chapter has also revealed there are very few Educational Technology studies that offer prolonged case-study analyses of technology use in K-12 schools, and even fewer engaging with feminist theoretical perspectives on gender. For this reason, Chapter 3 will now go on to explore feminist perspectives on gender, as applied in the fields of schools as organisations, education policy and technologies, with the view to draw insights from each that the present study can apply to address this gap in the existent educational technologies scholarship.

Chapter 3. Feminist perspectives: Gender and school organisations, policy and technology

Scarcely sixty years ago, neither the notion of feminism nor gender appeared in education research scholarship (David, 2015). Today, the dynamic body of work that constitutes 'gender and education' scholarship (writ large) encompasses a constantly evolving suite of diverse – often contesting - inquiries, theoretical investments, sites of analyses, and conceptions of gender (Bailey & Graves, 2016). Contained within this broad field of feminist scholarship are many insights that make possible the investigation of multiple aspects of girls' educational experiences in schools, including how organisational forms, policies, programs, and practices 'foreground gender and magnify its influence [or] put gender further in the background and diminish its influence' (Legewie & DiPrete, 2014, p.262).

Given this thesis is concerned with exploring the engagement of girls with Maker technologies in schools, it is necessarily informed by feminist scholarship and its aim to produce knowledge that is useful for the 'effective transformation of gendered injustice and subordination' (Ramazanoglu & Holland, 2002, p.147). This is appropriate given the relative absence of feminist perspectives in the theoretical discussions outlined in the first two chapters of the present study and that no Maker Education study has been found to date that explores how girls' engagement with Maker technologies in schools may be shaped and influenced by a school's internal social structures and/or broader historic, social, economic, and political context. Accordingly, the purpose of this chapter is to examine and draw theoretical insights from a range of feminist perspectives on gender with regard to organisations, education policy and technologies, with the aim of assisting this the present study's broader efforts to understand how gender exists and lives within contemporary school settings.

3.1 Caveats

Before proceeding, several caveats are offered for consideration. First, although throughout this chapter (and thesis) I make references to 'feminism/s', 'feminist/s' and 'feminist scholarship', I acknowledge that the voluminous body of work that constitutes 'feminist research' is made up of multiple and - times - competing philosophies. Thus, the selective range of perspectives presented in this chapter (and thesis) in no way argues for one feminist standpoint or that one feminist theoretical application has more import than others. Rather, the overview of feminist thinking presented here is better understood as a meeting point for many 'feminisms', a nexus that collectively assists my

broader efforts to engage, converse with and make sense of the findings generated from the present study's empirical activities.

3.2 Understandings of gender

In the early 1970s, most feminist education scholarship was dominated by references to sex differences and biological designations of 'male' or 'female' sex role theory (Francis & Paechter, 2015, p.776). Catherine Spade, Mary Trautner and Joan Valentine (2019) assert that such dichotomous views presuppose that gender encompasses two discrete categories – masculine/men and feminine/women – wherein displays of 'masculine' and 'feminine' behaviour are explained to be either an automatic response to innate personality characteristics and/or biological sex characteristics such as hormones and reproductive functions. Helping to shift this feminist gaze away from static prescriptions of biological sex differences and sex role theory was Ann Oakley's seminal work, *Sex, Gender and Society* (1972) wherein Oakley argued

> 'Sex' is a word that refers to the biological differences between the male and female: the visible differences in genitalia, the related difference in procreative function. 'Gender' however is a matter of culture; it refers to the social classification into 'masculine' and 'feminine' (Oakley, 1985, p.16).

Here, Oakley (1972) is credited with facilitating a theoretical turn in feminist education scholarship toward more complex understandings of gender (Frances & Paechter, 2015) by advancing a theoretical construct that 'appeared to escape the essentialism of 'sex'' (p.777). This spurred feminist scholars to explore the notion that social constructions of gender and gender roles are a confluence of individual, institutional and societal expectations that are mutually informed by fluid iterations of historical, temporal, cultural and social contexts (Hill Collins, 2015).

Social constructivist understandings of gender emerging from biological essentialism expanded the binary categories of 'girl/woman' (and boy/man) to include an appreciation for how each gender is not passively determined but is rather dynamic, socially constructed, malleable and fluid, and therefore subject to change. Significant here is the importance placed upon a person's shifting interactions with their surroundings and the extent to which a person may (or may not) possess the agency to develop their own gender (Glasser & Smith, 2008, p.346). Accordingly, feminist education scholars began to examine the social practices and social hierarchies of schools more forensically, testing the promissory rhetoric of education being an 'instrument of democracy' and 'great social equalizer' (Bailey & Graves, 2016, p.683). In the decades that followed, a broad array of topics were

revisited and/or investigated, including: sexism, marginalisation and sex differences, equity in education access, organisational structures and practices of individuals and groups, the lived experiences of education for girls/women in male dominated education contexts and, how education subject/s and institutions are constitutively gendered (Bailey & Graves, 2016).

Inside schools, the mid 1980s-1990s witnessed a proliferation of 'gender monitoring' investigations particularly focused on gauging the extent to which girls were being denied educational opportunities. This involved: observations of teachers' daily practices, scrutinising faculty, department, and leadership demographics and analysing curriculum and assessment resources to discern the extent to which girls were being afforded opportunities to exercise their agency (see Table 3.1). With particular regard to curriculum resources, forensic examinations involving the collection, collation and analysis of statistics concerning the relative number and position of male and female students textually represented in curriculum resources was undertaken to ascertain not only how gendered content was socialising male and female students (Brugeilles & Crome, 2009), but also render visible the 'cumulative power of messages found in textbooks, alongside other representations, processes and practices of social stereotypes' (Bailey & Graves, 2016, p.698). Here David Olson (1989) describes school textbooks as 'the authorized version of a society's valid knowledge' (p.239) whilst other scholars theorised that the ideologies contained within textbooks, including views on gender, articulated the 'beliefs of powerful social groups that aimed to influence people to think in a certain way or to get other people to do certain things' (Widdowsow, 2007, p.6). Equally, other gender monitoring focal priorities highlighted examples of female students being rendered inferior or excluded from schooling activities, the erasure of women's accomplishments, and the identification of male-dominated teaching and leadership practices (Bailey & Graves, 2016).

Yet although gender monitoring in schools was welcomed by many feminist scholars, emergent also at this time were concerns that this application of social constructionism was complicit in creating the very problem feminist scholars were seeking to resolve. These concerns included: first, socially constructed categories of gender maintained fixed presumptions of absolute biological distinctions of men/boys, women/girls or male/female; second, there was no requirement for feminist scholars to engage with the organisational structures understood to contain girls' access to opportunities; third, socially constructed categories of gender obfuscated the need to examine the processes by which each category of men/boys, women/girls and male/female evolved; and last, socially

constructed categories of gender prioritised a fixed social order consisting of only two major categories related to each other by power, with no room to consider individual conflicts of interest (Connell, 2013b).

Here Raewyn Connell (2013b) further makes the point that the political consequences of engaging with socially constructed categories of gender is the 'muting' of feminist empirical investigations. This was because such studies leave unquestioned the social arrangements that prohibit girls' participation or access to opportunities in the first instance. In other words, socially constructed categories of gender - like biological essentialism - lack the 'practical politics' required to disrupt the dichotomies inherent in the social structures of schools - and the process of schooling - which produce (and/or reproduce) gender inequalities (Connell, 2013b).

Curriculum	Pedagogy	Assessment
Subject-choices, with girls opting or encouraged to opt for 'soft' subjects such as languages, history, and literature, while boys do 'hard' subjects such as maths, science, and technology because these lead to careers and better paid jobs.	Teaching styles which favour boys, such as lessons which focus on memorising abstract facts, as opposed to open-ended, process oriented tasks, which girls' favour.	Assessment styles which favour boys, such as multiple-choice questions, whereas girls are known to excel at course work. Marker bias, which gives boys' work higher marks.
Classroom Behaviour	Space & Place	Teachers
Boys' dominance in classroom interaction, which marginalises girls' participation. Girls' own lower self-esteem and self-confidence	Timetables, physical locations of learning spaces, the layout and configuration of classrooms, classroom rules, practices, and proscribed 'normative' codes of conduct in policy documents	Teachers' lower expectations of girls' achievements and/or interests in STEM subjects. Teachers' attitudes to gender values and beliefs that girls are 'passive' and boys are 'boisterous'

Table 3. 1 Summary of 'gender monitoring' focus areas

Rob Gilbert and Pam Gilbert's *Masculinity goes to school* (1998) also pinpointed contradictions in biological essentialist understandings of gender and called for researchers to do more than view schools as some form of 'neutral background' as they urged instead for scrutiny of entrenched structures more closely within schools, as exemplified by the continued emphasis on boys choosing 'male type' subjects and the emphasis of sport in schools (Gilbert & Gilbert, 1998, p.47). Similarly, Madeleine Arnot (2002) outlines how many feminist education sociologists actively sought a theory of gender relations to analyse the gendered nature of contexts, structures, and micro-processes of schooling, and how the structure and culture of schools is shaped by social relations. Here, Arnot (2002) particularly favours the influence of Raewyn Connell's (1987) more sophisticated account of

schooling and her conceptualisation of gender not as an 'expression of biology, nor a fixed dichotomy in human life or character' but rather as 'a pattern in our social arrangements, and in the everyday activities or practices which those arrangements govern' (Connell, 2013b, p.10).

3.3 Gender and school organisations

One of the enduring strengths of feminist perspectives is a focus on schools as organisational entities. Writing in 2011 Sandra Acker reported that feminist scholars focused on organisations in the 1980s and 1990s were quick to abandon biological essentialist and sex role conceptualisations of gender. Instead, these feminist scholars used the term gender to describe broad social patterns of organisational inequality, subordination and difference between women and men (Acker, 2011, p.66). Turning away from the 'counting bodies' approach and notions of fixed dichotomies (Martin, 2012), gender was instead advanced as an aspect of individual identity, experience and social-structural processes that could be found deeply embedded in organisations and institutions, including schools.

Acker (2011) outlines the idea of gendered organisations: 'To say that an organization . . . is gendered means that advantage and disadvantage, exploitation and control, action, and emotion, meaning and identity, are patterned through and in terms of a distinction between male and female, masculine and feminine' (Acker, 1990: 146). In other words, 'gender is embedded in hierarchical structures, jobs, divisions of labour, processes such as hiring and wage setting, in images of workers and managers, in interactions in the workplace, in work/family interconnections, and in individual constructions of identity' (Acker, 2011, p.67). Here, 'embeddedness' implies that the fundamental, taken-for-granted processes of constructing organizations and jobs are shaped by a gendered logic that is hidden behind a gender-neutral discourse' (Acker, 2011, p.67).

Further, Acker attributes systemic inequality in organisations to groups and persons in control of 'organizational goals and outcomes, work processes and decisions' (Acker, 2006, 110) who may also display a 'degree of rigidity of inequality' (Acker, 2011, p.70). For Acker, there are five bases of inequality for researchers to consider. These include:

(1) organisational processes and practices that create and maintain, or challenge, inequality.
(2) the visibility of inequalities.
(3) the legitimacy of inequalities.
(4) mechanisms of control and compliance.

(5) competing interests in changing or maintaining inequalities.

Here Acker (2011) also proposes researchers first identify then describe the dynamic interplay of internal organisational structures, processes, practices, and beliefs that reproduce pervasive and persistent gendered social structures which distribute men/boys and women/girls into different tasks and positions into an organisational gender regime (Acker, 2006; Conwell, 2009). Particularly useful to the present study is Acker's (2011) further notion of 'gendered substructure of organizations'; the place where interlocking gender processes and 'practices relating to and assumptions about the extra-organisational reproduction of members' are located (Acker, 2006, p.197).

Raewyn Connell (2009) further urges feminist scholars to consider how organisational gender regimes are 'historically constituted' (p.74). In other words, to examine how gender relations shape, and have been shaped by, organisational social practices over time. Summarising this approach in *Gender: In world perspective,* Connell (2009) argues gender is about:

> relationships, boundaries, practices, identities, and images that are actively created in social processes. They come into existence in particular historical circumstances, shape the lives of people in profound and often contradictory ways, and are subject to historical struggle and change (p.30).

Such understandings are foundational to Connell's (2009) fourfold empirical research model which she designed for researchers (and organisations) to better discern how gender relations live within their organisations. This model describes gender in relation to production and consumption (including access, allocation, and categorisation of individuals within an organisation's hierarchy), power exercised over individuals and a collective in the form of control, authority and force, emotions (positive and negative) expressed through relationships and/or attachments of people and groups organised along gender line and, symbolism as expressed through cultural expressions, artifacts, and social practices.

Specific to determining a school's organisational gender regime and how it relates to the processes of schooling, Connell (2013) further proposes researchers:

(1) undertake a 'structural inventory' of schools that is 'pushed toward a more complete exploration of a given situation, addressing all its levels and dimensions' (p.98).
(2) closely examine how gender is influenced by - and influences - variable structures of power located within and external to a school's immediate context.
(3) study how gender operates within social arrangements, social practices, and everyday activities.

(4) pay particular attention to how school structures socially define what is possible and what is not - including who has access and who is excluded from activities.
(5) identify sites of contestation where gender politics are enacted which, in turn may also become sites to locate potential interventions.

Buttressed by a substantive body of socio-spatial scholarship highlighting the reflexive relationship of space to practice and social action (Burnett, 2011, p.216), a growing number of feminist scholars applying a spatial materialist lens to their study of schools also reject the notion that the school itself is simply a neutral background to research action. Instead, spaces in schools are understood to be both socially produced and political in orientation, insofar they produce normative spatial social power relations. Here, rather than theoretically conceptualising space and spatial practices as fixed and concrete, or discrete entities wherein actions and exchanges are directly attributed to space (Acton, 2017), scholars instead suggest it is better to consider space and spatial practices as 'complex, changeable, discursively produced, and imbued with power relations' (Smith et al., 2016, p.590).

Building on the early scholarship of Doreen Massey (2005) and her notion that space exists only in and through the relations, Renae Acton (2017) argues that scholars who cast impressions of 'space' and the 'social' as independent entities silence the 'subtleties of space creation and action' and therefore render invisible the 'agency of spatial selves [which work within] material spaces to create new dynamics, new relationships' (p.141). Significantly, to develop a deeper appreciation of how the purpose and effects of space are produced via our interactions with the material, feminist scholars posit that our focus should be as much on the relationships, cultures and practices that operate within school buildings as the buildings themselves (Acton, 2017; Low, 2016; Fataar & Rinquist, 2018). Accordingly, place-making is best understood not so much as a natural occurrence but rather as a system of power relations manifested by rules that construct and define socio-spatial boundaries that determine who belong to a place and who is excluded (Tupper et al., 2008; McDowell, 1999).

Edward Soja's (1989,1996) conceptualisation of the spatial veil further illustrates how certain modes of thinking and activity perpetuate a dominant or heteronormative way of operating that is related to the gender regime of organisations; particularly with regard to how relations of gender can become obscured or rendered invisible over time. Here Soja (1989) calls for scholars to 'demystif[y] spatiality and its veiled instrumentality of power' (Soja, 1989, p. 61) by exploring the extent to which a school's-built environment becomes 'a landscape of domination'; a place where people engaging

with ‘the routines of daily life … are not conscious of domination [which means] the socio-spatial system is reproduced with little challenge (Sibley, 1995, p.76). Useful in this regard also is Gill Valentine’s (2001) description of schools as ‘social institutions that perpetuate a certain belief system, or ‘hegemonic discourse’ that is ‘literally inscribed in the landscape’ via the structures of educational policy and ideology as well as individual agency’ (p.5) and the more recent work of Dave Cudworth (2015) who reminds us that schools are ‘socially produced representations of spaces for teaching and learning [wherein] certain ‘representations’ about what schooling looks like in practice and what should go on in schools have been historically, economically and politically established’ (p.77).

Drawing from the scholarship of feminist geographers and educationalists who focus on the social location of power relations in everyday experiences and places, Jane McGregor’s (2006) study of gender within the spatial practices of schools unearths how powerful gendered discourses are constructed and maintained in school organisational spaces (p.2). Applying Doreen Massey’s (1994) seminal view that space is ‘a moment in the intersection of configured social relations’ (p.265) and the idea that the spatial and the social are reciprocally constructed through materially embedded practices and performances that create and maintain everyday social relations, McGregor’s (2006) subsequent application of Massey’s (1999a, 1999b, 1999c) ‘space-time’ conceptualisation does much to help the present study’s effort to surface the dynamic interrelations of gender with space, time and social relations in my chosen school research site.

Asserting that ‘social relations and processes sediment into certain patterns which are reflected in persistent physical and organisational (and power) structures such as the classroom’, McGregor (2006) also emphasises the need to consider how historical operational aspects of schooling - understood as particular configurations of socio-spatial relations that are constantly performed and remade by gendered power relations - change over time. These ‘configurations’ (p.6) include considering:

(1) the way the timetable and physical layout of a school imposes rhythms and constraints within a repetitive cycle.
(2) the connection of school rules and practices to spatiality and embodiment.
(3) how spaces are used by students.
(4) the regulation of student access to spaces by adults.

(5) how teachers draw on the production of space in the classroom to exercise their authority and maintain power relations, through controlling and regulating movement, noise and even light.
(6) how students use space to comply or enact resistances.

Adding another layer of complexity, Annegret Staiger (2005) advocates understanding a school's physical buildings as 'allow[ing] certain movements and prohibit[ing] others, like the timetables that prescribe the daily activities' (p.568) whilst Jennifer Tupper, Terry Carson, Ingrid Johnson and Jyoti Mangat (2008) affirm that the built environment of the school - including the aesthetics of the school building 'contribut[es] to the many ways in which students move through, occupy, and feel about particular school spaces' (p.1067).

Also affirming the dynamic nature of socio-spatial relations is the more recent work of Ceridwen Spark, Libby Porter and Lisa de Kleyn (2019) who make the point that feminist research in this area 'often fails to properly account for how space is at work' (p.5). Accordingly, the authors contend that the repeated rhythms and constraints of socio-spatial relations in schools not only 'take place in a context saturated with meaning, already configured by institutional structures and socio-cultural realities and intensively conditioned by physical space' (p.5) but also that gender should not be read as uniform across all contexts because its manifestation changes over time and with age. Relatedly, Yihan Liu and Christopher Grey (2018) understand the relationship between space and gender as a production process that is based on relation and demarcation wherein 'both space and gender are constructed and evolve constantly in interaction with political, economic and historical forces' (p.645). For this reason, Liu and Grey (2018) also advocate researchers closely examine how gender relates to the 'movement between and within organizational spaces [which] relies on the continual and complex articulation of spatial rules and resources: access and exclusion; speed and direction; posture and comportment' and material 'fixtures, walls, corridors' (p.646).

3.4 Gender equality policy in schools

Another focus of feminist scholars of education is the coming together of gender and policy, not least policy efforts to address issues of equity. Pivotal to the present study's efforts to better understand girls' engagement with Maker technologies in school settings is an understanding of how the gender order of wider society shapes and influences gender equality inside schools. Accordingly, the focus of this chapter now turns to the meanings of gender expressed in Australian gender equality education policies published since 1975. Doing so accords with Raewyn Connell's advice for

researchers to examine how 'features of gender relations operating in wider society, or society's *gender order*' influence a school's organisational structures, relationships, practices, and processes, and how these internal expressions reproduce, depart or reverse broader gender order gender relations (Connell, 2009 - emphasis mine).

The trajectory of gender reform in education policy that began in Australia just on five decades ago addressed feminist concerns over sex-role socialisation, sex stereotyping, self-esteem, and role modelling. Over the next twenty years, the focus turned to encouraging girls to undertake subjects - and post-school career pathways - in 'non-traditional' curriculum areas (Kenway, 1997, p.331). This was at a time coinciding with the 'Federal Government's attempts to 'kick-start' the economy by stressing the importance of science, mathematics, and technology for growth and by subsidising these fields' (Kenway, 1997, p.331). Notable in these various policy iterations is the persistent influence of categorical understandings of gender associated with liberal feminism's project of affirmative politics.

Undergirding the first gender equality reform policy, *Girls, Schooling and Society* (1975), was a perception of inferior and passive girl narratives of femininity and homogenised notions of gender difference (Keddie, 2005, p.22). Thereafter, underwriting *The National Policy on the Education of Girls* (1987) was a liberal feminist sex-role categorical understanding of gender whose political motivation was to redress gender disadvantage (Kenway, 1997). Occurring at a time when government economic rationalism and corporate managerialism was making difficult the prospect of attending to matters of gender justice, this policy helped 'disrup[t] the strongly gendered patterns of subject choice perpetuating Australia's highly sex-segregated [STEM] labour force' (Keddie, 2005, p.26). Consequent to schools' implementing *The National Policy* (1987)*,* broader socio-political forces associated with the global shift toward neoliberalism (Keddie, 2005; Lingard, 2003) ultimately led to the replacement of *The National Policy* (1987) gender reform policy with *The National Action Plan for the Education of Girls (1993-1997).* This latter policy framework significantly announced Australia's first (and only) attempt to apply relational understandings of gender to alter prohibitive institutional patterning of gender embedded in school structures and schooling practices. Exhorting this period as 'unequivocally the product of new times in Australian history' (Kenway, 1997, p.330) *The National Action Plan* was considered a landmark moment by many feminist scholars of education,

organisation, and policy insofar it was the first time that gender - for boys and girls - was thought of as being constructed and reconstructed within school cultures, and across the curriculum.

Yet this relational focus of gender in the construction of education policy did not last. Keddie (2005) and Lingard (2003) suggest its demise can be attributed to the broader influence of socio-political imperatives associated with neoliberal market agendas - efficiency, de-regulation, competition, standardisation, and a culture of performativity - together with rising controversies about boys, men and education that were 'boiling up in a number of countries' over 'boys academic 'failure' relative to girls' (Connell, 1996, p.202). Within this context, the next (and current) national gender equality reform education policy statement: *Gender Equity: A Framework for Australian Schools* (1997) proposed a view of girls that encouraged the public to consider that girls are now 'fixed up' (Keddie, 2005, p.29), and a return to understandings of gender that emphasised equitable access rather than challenging institutionalised patternings of gender both within and beyond schools (Keddie, 2005, p.26).

Henceforth, liberal feminism's binary affirmative politics, and its dichotomous categorical understandings of gender, were yet again affirmed – and consolidated – both in schools and the public's imagination as the new *Gender Equity* policy began to address education equity issues 'for boys *as well as* girls, rather than boys *in relation to girls*' (Keddie, 2005, p.28 - emphasis mine). Sidelined from this point was the 1997 relational view of gender and its advocation for schools to closely examine how understandings of gender were woven into - and expressed through - organisational structures and - more significantly - how these social structures lead to 'structural disadvantages and power differentials experienced by women' (Lingard, 2003, pp.35-36).

It is perhaps unsurprising therefore that 'gender equality is absent as a priority' (McKnight, 2018, p.224) in Australia's current iterations of curriculum policy and there is barely a nod to feminist perspectives on gender in the 'ferment' and 'hyper-activity' (Ball, 2019, p.747) of recent education policy scholarship. Pointing to this invisibility of feminist perspectives are recent Educational Policy studies examining teacher and leader responses to policies aimed at monitoring and improving the quality of teaching (Lewis, Savage & Holloway, 2020; Barnes & Cross, 2018); the use of data and implications of datafication on teacher accountability (Madsen, 2021; Hardy, 2021; Neumann, 2021); explorations of policies related to teacher training (Hardy, Jakhelln & Smit, 2020); and studies of how teachers (Gowlett et al., 2015) and school leaders (Cousin, 2020) understand or react to education

policy reforms, particularly those purporting to address issues of social justice (Molla & Gale, 2019) or improving access and equity for students with disabilities (Whitburn et al., 2017). This is despite each of the aforementioned areas clearly influencing the working and learning lives of leaders, teachers and students who work - together and apart - in contemporary schools, including Greenfield College.

Furthermore, most recent studies of STEM education policy also appear to perpetuate feminist binary categorical understandings of gender as a demographic descriptor or more subtly through their alignment of STEM and girls to neoliberal economic agendas. For example, gender appears as a static demographic category of analysis in studies of the emergence of STEM in schools (Peters-Burton et al., 2020; Carter, 2017); measuring business (Hite et al., 2020) and teacher engagement (Hite et al., 2020) with STEM education strategies (Williamson et al., 2019; Murphy et al., 2019); government efforts to improve the STEM workforce (Sharma & Yarlagadda, 2018) and the positioning of STEM education as a driver for economic prosperity (Barkatsas et al., 2018). Illustrative here too is David Ellis and P. John Williams' (2020) comparison of STEM education policy in Australia with other Organisation for Economic Cooperation and Development (OECD) member states which outlines how STEM policies have attempted to address the 'gender gap', 'gender bias' and 'gender stereotyping' in STEM fields, female teacher shortages in STEM subject areas and the apparent deficit of girls' confidence in STEM areas. Significantly, Ellis and Williams (2020) further explain that state and local policy strategies in schools have sought to 'inspire girls in choosing to do STEM subjects … using strategies to *push back at STEM gender stereotypes*' (p.433 - emphasis mine), including the very focus of this thesis i.e., using the strategy of Maker Education in schools.

Making a small dent in this pattern of absence are a few recent Educational Policy studies advocating the use of qualitative research methods to discern how gender is constructed inside schools and education systems. Exemplifying this trend, Bryan Duarte (2020) examines principals' perceived levels of instructional influence and teachers' perceptions of working conditions using a critical ethnographic methodological approach and theories of subjectivity; David Gillborn, Paul Warmington and Sean Demack (2018) employed critical race theory to surface hidden assumptions about race and gender encoded within seemingly objective quantitative data sets; whilst Wendy Cumming-Potvin and Wayne Martino (2018) unpacked what they call the 'Western Australian *Policyscape*' (p.716) by drawing on transgender, queer and policy theories when exploring how opposing political forces impact the commitment made by the state education system to support transgender and non-binary

students, and their families.

Helping us understand why – for the most part - binary categorical understandings of gender continue to dominate Australia's Educational Policy landscape is Australia's subscription to the OECD's global gender equality strategy, gender mainstreaming (GM). From the 1980s, Australia joined other United Nations (UN) Member States in making a commitment to deliver the UN's GM strategy to globally improve women's social, economic, and political conditions (Scala & Paterson, 2017). As an approach to policy design and analysis, GM was designed to replace previous 'special measures' strategies (such as women-specific programs and projects) in Member States (Teghtsoonian, 2003). Accordingly, Australia committed to integrating considerations of gender into all public policies and all aspects of public policy work, including development, planning and evaluation to deliver both national - and contribute to global - gender equality objectives (Fredendall & Ramberg, 2019, p.2).

Revealing here is Australia's submission to the 2017 biannual *Progress Report Australia to UN Women* (2017) which created an impression that on the public institution front (including schools), Australia had made considerable gender equality inroads by applying the UN's GM policy strategy in the Australian STEM educational landscape:

> Through an investment of AUD13 million over five years under the National Innovation and Science Agenda, the [Australian] Government is providing women with the skills and support they need to work in growth industries by *getting more women into* science, technology, engineering, and maths. It is also investing AUD 31.2 million in internships and post-school career advice to increase support for women to study and work in STEM (UN Women, 2017 - emphasis mine)

This was despite little changing in actuality to improve gender equality in the Australian national education landscape. In this regard, feminist scholars have long argued that despite GM's 'transformative capacity' to reveal 'male norms in structures and processes, thus enabling new understandings of how gender operates in policy making' (Fredendall & Ramberg, 2019, p.2), little is changed by the GM strategy because it is a poorly understood 'hollow' (Subrahmanian, 2004, p.90), 'fuzzy', 'contingent' and 'elastic' (Daly, 2005, p.439), and a 'kind of chameleon, changing colours with every social and political context' (Verloo, 2005, p.355).

Of specific relevance to the present study is the way many OECD Member States - including Australia - have depoliticised the transformative potential of the GM strategy. Here feminist scholars argue that GM has been reduced to 'a question of methods and checklists for bureaucrats rather than

conflicting ideas, values, and opinions;' thus ensuring GM related initiatives are 'merely cosmetic' (Freidenvall & Ramberg, 2019, p.3). Significantly, Francesca Scala and Stephanie Paterson (2017) further suggest that a fundamental flaw of GM is the lack of attention to the UN's requirement for all public institutions - including schools - to 'closely examine the institutional practices and norms' (p.579) within organisational structures. Ergo, the 'technocratic and non-systemic [GM] implementation approaches' enacted by Member States - including Australia – fails to address both the significant social causes of gender inequality and the relationship between GM and social change (Daly, 2005, p.433).

Of interest here too is that whilst on the one hand GM is understood to hold the potential to effect public policies that make profound structural changes in public organisations - including schools – so as to effect gender equality, on the other feminist scholars continue to argue that instead of focusing on delivering gender equality, the GM strategy is instead 'working hand in glove with neoliberal political agendas where women are produced as 'individuals' and gender is disconnected from power (Rönnblom, 2005, p.165). Here some feminist researchers go so far as to argue that the GM policy 'conundrum' is further exacerbated by the way GM is being 'bent' to fit neoliberal policy goals (Lombardo et al., 2009), thus becoming an 'open signifier that can be filled with both feminist and non-feminist meanings' (Lombardo & Meier, 2006, p.161) of gender equality.

In the Australian context, feminist concerns that the OECD's GM strategy is muting the political dimensions of gender (Milward et al., 2015; Andersson, 2015) appear borne out by Australian government policy positions (and publications) on GM that cement binary categorical understandings of gender: 'gender equality is a goal to ensure equal rights, responsibilities and opportunities of women and men, girls, and boys' (AGOW, 2012, p.50). Particularly significant to the present study is the absence of a commitment to examine gender in relation to the 'institutional structures and processes' as outlined in Australia's 2012 definition of 'Gender Mainstreaming':

> Gender mainstreaming entails bringing the perceptions, experience, knowledge and interests of women and men to bear on policymaking, planning and decision-making. It does not replace the need for targeted, women-specific policies and programs, and positive legislation; nor does it do away with the need for gender units or focal points (AGOW, 2012, p.50).

Connell (2009, 2011) argues that Australia's refusal to examine institutional structures and processes in schools is in large part due to the nation's neoliberal political agendas which have recast 'gender

equity' in the neoliberal terms of efficiency, competitiveness, and the individual attainment of economic equity (Connell, 2009, 2011).

Underwritten by a 'theory of political economic practices that proposes human wellbeing can best be advanced by liberating individual entrepreneurial freedoms and skills' (Forsey, 2007, p.1), neoliberalism lives deeply embedded within Australian schools, advanced and consolidated by institutional frameworks that advocate expanding education markets and deploying market principles across school systems (Lipman, 2011, p.116). This means Australian schools have long been restructuring their education systems to suit 'human capital development to prepare students for new types of work and labour relations by setting objectives, performance targets and introducing ongoing, standardised testing to steer the curriculum and pedagogical practices to ensure these targets are efficiently and effectively met' (Lipman, 2011, p.117). Accordingly, well established principles of neoliberal market agendas in Australian schools have 'redefined the purpose of education and what it means to teach, learn and participate in schooling' (Lipman, 2011, p.119). In practice, this is made manifest by:

(1) decentralisation turning schools into firms competing with each other for pupils, resources, and academic results 'an overt manner to prove their worth' (Forsey, 2005, p.18).
(2) students and parents being understood as stakeholders or 'clients' and the school 'touting' for their business or at least creating a market niche through the creation of a distinct product (Forsey, 2006).
(3) the introduction of state and national testing mandates, leading to schools to 'jockey for position in competitive markets' (Connell, 2013, p.106).
(4) top-down accountability measures for teachers (Lipman, 2011).
(5) standardised tests and performance outcomes driving curriculum and pedagogy.
(6) managerial principals leading school cultures where learning equals performance on tests with teachers, students and parents held responsible for 'failure' (Lipman, 2011, p.118).
(7) an increasing sway of policies about achievement, tests and learning outcomes explicitly influencing the way teachers practice their teaching (Hedegaard-Soerensen & Grumloese, 2020, p.642).

For the purposes of this study, Lipman (2011) provides a particularly useful summary of the impact of neoliberal market agendas on schools and schooling:

> education, which is properly seen as a public good, is being converted into a private good, an investment one makes in one's child or oneself to 'add value' to compete in the labour market. It is no longer seen as part of the larger end of promoting individual and social development but is merely the means to rise above

> others. Democratic participation in local schools is rearticulated to individual 'empowerment' of education consumers (Lipman, 2011, p.118).

Further significant to this study's focus on girls' engagement with Maker technologies is Linda Colley and Catherine White's (2019) suggestion that schools now affirm a brand that lauds 'the opportunities and choices available to all' which projects - for girls in particular - the notion that 'all women have the same opportunities and circumstances that are for them unfettered life choices' (p.1093).

Seeking to give conceptual clarity to the term 'post feminism', Rosalind Gill coined the notion of 'postfeminist sensibility' to make 'sense of paradoxes and contradictions in the representation of women' (Banet-Weiser et al., 2020, p.4). Steering away from the various meanings attributed to 'post feminism' - a term used as a temporal marker or to describe a new type of feminism or a feminist backlash – the notion of a postfeminist sensibility instead encouraged feminist scholars to see 'post feminism' as a critical object rather than an analytical perspective; thus encouraging a focus on the circulating 'set of ideas, images and meanings' associated with broad cultural manifestations and features of a postfeminist sensibility (Banet-Weiser et al., 2020, p.5).

Relatedly, Catherine Rottenberg (2014) outlines how many feminist scholars in the 1990s and beyond felt that neoliberalism 'hijacked' and 'colonised' mainstream feminism by entrenching a neoliberal rationality that sought to abrogate the group struggle and collective responsibility of feminism. Affirming an understanding of neoliberalism to mean not only a set of economic policies but also a political force that recasts individuals as human capital and thus 'capital enhancing agents' (Banet-Weiser et al., 2020, p.8), Rottenberg attributes her coining of the term 'neoliberal feminism' in *The Rise of Neoliberal Feminism* (2018) to the influence of Angela McRobbie's (2009, 2015) notion of post feminism and Rosalind Gill's (2007, 2011, 2016, 2017, 2018, 2019) considerable work on postfeminist sensibilities (Banet-Weiser et al., 2020, p.7).

However, whilst acknowledging overlaps between postfeminist and neoliberal feminist outlooks, Rottenberg (2014) differentiates 'neoliberal feminism' by suggesting it is a form of feminism that avows gender inequality whilst simultaneously disavowing the socio-economic and cultural structures shaping our lives. Here a new feminist subject is created who fully accepts responsibility for her own wellbeing and self-care (Banet-Weiser et al., 2020, p.7). Rottenberg's (2014) understanding of neoliberalism as a political rationality goes on to argue that all social, economic,

political, and affective aspects of life - for both men and women - are ultimately reduced back to market metrics. Accordingly, neoliberal feminism espouses elements of 'hyper-individualism' and females as 'entrepreneurial subjects and individual enterprises' whose prime interest is in achieving economic and professional success overrides concerns for or about the 'structural or economic undergirding' of continued gender inequalities suffered by the collective (Banet-Weiser et al., 2020, p.8).

It is at this juncture that the contradictory nature of neoliberal feminism is revealed. On the one hand, the way neoliberal feminism supplants individual responsibility (and success) appears to forge a form of feminism that bears little semblance to liberal feminism whose 'raison d'être' was to pose an immanent critique of liberalism, revealing the gendered exclusions within liberal democracy's proclamation of universal equality, particularly with respect to the law, institutional access, and the full incorporation of women into the public sphere. This is because unlike its forbearer, neoliberal feminism appears to offer no critique of neoliberalism. Yet, in its promotion of individuals pursuing success only for themselves, an adversarial, competitive ethos that pits one individual against another is created, thus affirming, consolidating, and reinscribing biological essentialist categorical understandings of gender associated with liberal feminism (Rottenberg, 2014).

Furthermore, by casting radical, socialist and liberal feminism adrift as seeming relics of the 'past that ha[ve] achieved [their] initial goal and [do] not represent contemporary concerns' (Colley & White, 2019, p.1092), neoliberal feminism instead equates gender equality to individual economic empowerment. Derived in part from the aforementioned 'rhetoric of competitiveness within a world building itself back from the global financial crises' (Colley & White, 2019, p.1092) women's empowerment under the auspices of neoliberalism is now largely understood as being inextricably bound up and justified with profit outcomes.

These economic logics announce their presence in schools in the form of external corporate sponsorships or mentorship programs, not-for-profit self-empowerment programs, local business, or council partnerships and/or entrepreneurial skill training workshops offered largely to female leaders pursuing management careers or girls, particularly those considering the pursuit of commerce or STEM career pathways. Here, successful female entrepreneurs are brought into schools to advance the state's long held ambition to push more girls into STEM subjects and career pathways, urging girls and women to overcome 'imposter syndrome' and to 'lean in' to the challenge of male-dominated

fields to become professionally and economically successful. Particularly relevant to the present study is that the determination and substantive investment by the state to teach 'girls and women to code in computing, as a way to address the marginalisation of women in technology subjects' (Banet-Weiser et al., 2020, p.11) is co-dependent on individual girls and women applying their own considered energies and ambitions, rather than the state examining the structures of institutions (including schools) or society more generally to realise their success.

Shared across both post feminism and neoliberal feminism are narratives of 'successful girls' and 'girl power' (Banet-Weiser et al., 2020, p.4); each underwritten by elements of individualism, entrepreneurialism and an emphasis on successful personal transformation (Banet-Weiser et al., 2020, p.9). Here, Rottenberg (2014) particularly notes that neoliberal feminism argues for individual women to focus on themselves and their own aspirations. In this sense, female students are encouraged to see themselves as responsible for enhancing only their own well-being whilst simultaneously turning away from yesteryear notions of collective action. For Rottenberg (2014), this constitutes 'a new regime of morality [that] links moral probity even more intimately to self-reliance and efficiency, as well as to the individual's capacity to exercise his or her own autonomous choices' (Rottenberg, 2014, p.421).

Accordingly, under the auspices of neoliberalism, every individual student's experience in school can be reduced 'to a calculus of utility, benefit, or satisfaction' wherein the various apparatuses of the school will provide standardised pedagogical 'institutional practices and rewards' to support the realisation of the neoliberal vision of success (Brown, 2005, p.39). Thus, the model student will be recognised positively for 'strategising for him/herself among various social, political, and economic options' rather than working with others to alter and organise these options for the collective benefit. Here no longer required - or indeed expected - will be notions of collective effort - or reflection - as the entrepreneurial student will instead exercise personal choices and initiative to improve personal career prospects that are measured only on each individual's capacity to achieve economic equality (Rottenberg, 2014, p.427).

Offering a corrective to neoliberal education reforms that see the teacher controlling all aspects of student learning experiences in schools, feminist pedagogy offers 'a vision of what education might be like but frequently is not' (Shrewsbury, 1997, p.166). Whilst over the past two decades the vision of feminist pedagogy has fragmented into a diverse range of dynamic, evolving practices, shared in

common across all is a resolute focus on 'emancipation and liberation underpinning what is taught and how it is taught' (McCuskey, 2017, p.446) and a refusal to treat students as customers with individualised problems (Naskali & Keskitalo-Foley, 2019, p.11). For this reason, feminist pedagogues reject understandings of teaching methods and assessments as politically neutral acts and instead propose:

1. Learning is [and should be] a lifelong process of continual transformation.
2. Pedagogues are fellow learners, not experts who "deposit" knowledge "in" students.
3. Situated knowledge(s) are legitimate forms of knowing.
4. Multiple voices and opinions are enriching to every issue.
5. Education should challenge, not reinforce, unquestioned norms and injustices in society.
6. Theory and practice are interconnected and should not be separated. (Martin, 2017, p.99).

Contemporary feminist pedagogy scholars (Ylöstalo & Brunila, 2018; Belliappa, 2020; Elwell and Buchanan, 2021) challenge the neoliberal pursuit of standardisation and pedagogical 'sameness' by recognising the 'genderedness of all social relations and consequently of all societal institutions and structures' (Shrewsbury, 1997, p.167). Necessarily rejected are school structures that maintain (if not expand) the distance between teachers and learners (Belliappa, 2020, p.107), 'banking model[s] of education, where teachers directly transmit knowledge into the minds of students' (Martin, 2017, p.7), views of students as 'deficient in some way, and thus not ready, willing or capable to participate' in learning tasks and - most importantly - the positioning of the 'all-knowing' teacher as the 'sole proprietor of knowledge' (Martin, 2017, pp.7-8) at the front and centre of all classroom interactions.

Lying at the heart of feminist pedagogy is the aim to deconstruct the supposedly gender-neutral nature of knowledge and the student-teacher relationship (Ylöstalo & Brunila, 2018, p.920). Thus, to address unequal gender relations, feminist pedagogues call into question neoliberal gendered practices and structures of education (Naskali & Keskitalo-Foley, 2019), actively prioritise notions of the collective, seek to create community (Hess & Macomber, 2021) and attempt to develop within their students an appreciation that the relational process of learning is more important than the product. Further, rather than the neoliberal focus of teachers' teaching and maximising the efficiency of students' learning experiences, feminist pedagogy instead prioritises learners developing shared understandings of how answers are formulated, why particularly forms of social, cultural, and historical knowledge is considered legitimate (or not) and how hierarchical schemas of power operate.

Significantly, feminist pedagogy's emphasis on the social context of learning and determination to 'teach differently' at the local level holds 'converging aims with gender equality work' (Ylöstalo & Brunila, 2018, p.930). This is because both encourage the development of 'democratic spaces where students take ownership of projects and classroom conversations' and teachers encourage students to 'question how relations of power and knowledge are constructed and maintained, including the classroom itself' (Martin, 2017, p.31). Thus a 'feminist pedagogy of gender equality' (Ylöstalo & Brunila, 2018) encourages teachers to enact conscious intent, develop awareness of prohibitive social and material conditions (Elwell & Buchanan, 2021, p.167), and prioritise the social to create 'spatial and temporal ruptures in power relations' (Ylöstalo & Brunila, 2018, p.930).

3.5 Feminist perspectives of schools and technology

Over the past several decades, feminist scholarship in the field of gender and technology has progressively built an understanding of technology that includes not only artefacts and processes of production but also the cultures and socio-political practices associated with the design and configuration of these technologies. Accordingly, consistently held within much of this broad theoretical purview is the idea that technologies are not neutral artefacts because they embody socio-cultural relations made up of a disparate suite of knowledge, beliefs, desires, and practices (Wajcman, 1991).

Feminist technology studies (FTS) have been the most prominent strand of feminist research on gender and technology since the 1980s. Historically developed from the 1970s feminist movement and feminist scholarly interest in the gendered power dimensions of technology in the 1980s (Lageson, 2015), early FTS scholars challenged the exclusion of women from many technological areas and public spheres, including the liberation narratives associated with household appliance technologies and biomedical reproductive technologies. Here FTS scholars instead expanded understandings of the relationship between masculinity and technology (Wajcman, 1991; Lageson, 2015) by situating constructions of girls/women as deficit in relation to technology within broader historical, social, and cultural contexts (Cockburn, 1985; Franklin, 1992; Noble, 1992,1995).

Significantly, these studies took as their starting point the notion that technological competence is an integral part of a masculine gender identity and therefore the exclusion of girls and/or women or their so-called 'deficit' relationship with technology was a historical construction designed to affirm

the primacy of masculine culture. Affirming this view, Judy Wajcman (1991) asserts, 'as with science, the very language of technology is masculine. It is not simply a question of acquiring skills, because these skills are embedded in a culture of masculinity that is largely coterminous with the culture of technology' (p. 19). In other words, technology is not simply an artefact. Rather, it holds and expects a series of masculine practices and knowledge points that work to regulate and define how technology is used by men, therefore alienating, marginalising, or excluding women (Cockburn, 1985; Wajcman, 1991; Noble, 1992, 1995).

Still resonating today in government publications urging more girls to consider career pathways in the field of STEM are 1990s government concerns about the lack of female engagement with Computer Sciences (Margolis & Fisher, 2002) and Engineering (Frehill, 2004; McIlwee & Robinson, 1992) career pathways. Of interest to the present study is that still some thirty years later not only is the question 'why so few' girls or women still being asked, but so too is the 'problem' still being attributed to deficits and individual responsibility of girls' 'lack [of] interest, skills, courage, motivation' which can be solved by simply 'informing and encouraging more women to make their way into these areas' (Lageson, 2015, p.5).

Yet as with much of the feminist scholarship already surveyed in this chapter, feminist scholars of gender and technology did not leave unchallenged these biological essentialist 'deficit' understandings of girls/women. To the contrary, from the late 1990s many shifted their focus away from 'deficit' views of girls/women and instead toward deficits within institutions and organisations themselves. This is exemplified in Jane Margolis and Allan Fisher's seminal text 'Unlocking the Clubhouse' (2002):

> Despite doubts and uncertainties, women tend to persist in computer science when they reject and find alternatives to the dominant culture in the field. A larger question, though, is what institutions can and should do to eliminate the negative factors that lead students to leave computing programs (p.107).

Likewise emphasising the institutional 'situatedness' of technology, Wendy Faulkner (2001) advanced a theoretical perspective of the co-production of gender and technology that proposed both a reciprocal shaping of gender and technology and the need to differentiate gender relations by considering gender *and* technology, gender *in* technology and gender *of* technology. In this sense, Faulkner's (2001) constructivist feminist framework 'defies the kind of simplistic treatments in which technology is seen as either unproblematically a product of male interests, or as neutral' (p.90). Rather, determinist views of technology were challenged by acknowledging that 'individual

technologies are subject to considerable interpreted flexibility in both use and design' (p.90). Thus, consideration of the 'situatedness' of girls/womens' use of technology in organisations - including schools - should also scrutinise liberal feminist campaigns to increase the participation of women in technology which perpetuate fixed biological essentialist notions of girls/women in relation to technology (Faulkner, 2001).

Moving beyond these binary views of gender are materialist-feminist technology studies in schools. Inside the classroom, Kathleen Kummen's (2015) application of a material-feminist theoretical perspective advances an understanding of learning with technology that considers more than the internal cognitive processes of the individual learner or cognitive processes arising from interactive encounters with other humans. Instead, Kummen (2015) brings into the gender and technology theoretical frame what she calls the 'agentic force of the matter of learning, such as text, images, space, time' (Kummen, 2015, p.807). Here Kummen (2015) draws particularly from Barad's (2007) materialist-feminist understanding of 'a 'doing' or 'being' that sees 'matter as mattering, the materials, books, and images that are included or excluded from the activity of learning matter' (p.216) and Barad's (2007) advice to attend to the 'political issue' (p.216) of spaces where material entanglements create exclusive or inclusive learning realities for girls (and women).

Also focused on the impact of social forces and material conditions on gender and its relationship with technology is the contemporary *Data Feminism* work of Catherine D'Ignazio and Lauren Klein (2020) which usefully outlines six core principles of a feminist perspective: rethink binaries; embrace pluralism; examine power and aspire to empowerment; consider context; legitimize embodiment and affect; and make labour visible. Here, like the contemporary scholars already discussed, D'Ignazio and Klein (2020) affirm their feminist approach is underwritten by two key elements, including the need to expand their research design frame to account for a range of social forces and material conditions; and focus on the relational by insisting that data, design, and community of use, are inextricably intertwined.

3.6 Summing up and looking forward

This chapter has provided a rich overview of understandings of gender expressed in feminist scholarship in the fields of gender and organisations, education policy and technologies spanning the past several decades. Doing so revealed that whilst on the one hand feminist perspectives on gender have expanded substantially on the other, understandings of gender expressed in education,

organisations, technology, and policy - particularly in 'gender equality' and STEM policies focused on increasing the engagement of girls/women in STEM fields – perpetuate fixed binary categorical understandings of gender that feminist scholars across each of the aforementioned fields have been rejecting for many years.

Yet the purpose of this chapter was not to more explicitly define or characterise the relationship that exists between gender and educational organisations, policy, or technology in the hope of bringing some form of resolution to a problem that has been more than thirty years in the making. Rather it should instead be considered as providing an amalgam of theoretical perspectives that can now be applied to the present study's broader efforts to construct a working theoretical framework to inform both the methodology and analyses that follows.

Accordingly, this study will now draw from the range of place-based, material and feminist theories considered in the previous three chapters to consider the gendered nature of schools and schooling more fully, and most significantly, develop the idea that girls' engagement with Maker technologies in schools is best understood as deeply embedded in the social world. Here the theoretical insights offered by Chapter 2 and Chapter 3 are used as 'both a point of reference and point of correction' (Selwyn, 2012a) insofar as each is duly considered when determining the research design, methods, types of data collected, and the nature (and complexity) of the 'pointed and difficult questions' (Philip & Garcia, 2015) that will be asked thereafter to make sense of the 'messy and bumpy textures and terrain' (Wheatley, 1994, p.413) of the data-sets generated by the present study's empirical activities.

Chapter 4. Methods

Unlike much of the Maker Education scholarship explored in Chapter 1, this thesis makes no attempt to explain, measure the efficacy, or report 'best practice' with respect to girls' engagement with Maker technologies in schools. Rather, a qualitative ethnographic approach and place-based methods are used to build a thick description of the broader socio-political context of its research site in a manner that values particularity, complexity, and relationships. Adopting this approach provides for the later application of feminist theoretical perspectives outlined in Chapter 3 in a manner that 'tease[s] out meanings' that attach gender to girls' engagement with Maker technologies in schools 'at the micro, meso *and* macro level of inquiry' (Selwyn et al., 2018, p.21). Significantly, doing so also troubles prevailing explanations for girls' engagement with Maker Education that perpetuate the view that the responsibility for girls' lack of interest or engagement lies with (and within) individuals (see Chapter 3).

4.1 Research Approach

Informed by a social constructivist worldview, the aim of this study is to surface the complexity of girls' (aged 12-16) engagement with Maker technologies in one co-educational high school in Melbourne, Australia. Central to this approach is the understanding that societal (and staff) views of girls' engagement with Maker technologies are situated, negotiated, and shaped by the social, historic, and political context in which the phenomenon of girls' use of Maker technologies takes place.

Here Crotty's (1998) assumptions are applied to guide the design of this study. With regard to generating data, open-ended questions are used to enable all staff to share their views. Thereafter, because researchers construct meanings most fully when immersed in the world they are investigating, researchers should personally engage with the process of data generation wherever possible. Moreover, when making meaning of their datasets it is incumbent upon researchers to appreciate that their generation of meaning is both inductive and relational, arising in and out of social interactions, and the historic, social, and political situational context of their staff.

Furthermore, because this study specifically focuses on issues related to gender equality, its research approach is also informed by some aspects aligned to a transformative paradigm. Here Mertens (2010) usefully outlines the key features of this research worldview, including how usually marginalised individuals and experiences are placed in the centre of research efforts. Here, concern

is given to how individuals and experiences have been constrained, how such constraints are subverted and how inequity results in asymmetric power relations. In this sense, researchers not only make a link between political and social relationships but also apply theories to better understand why problems related to power exist.

4.2 Research Design

Fieldwork for the present study took place over a ten-week period from October– December 2018, corresponding to the last term of the academic school year. My decision to inhabit the school for this period of time was premised on a desire to add depth to the present study's contextual understanding of the ebb and flow of the school's 'patterns of regular happenings' (Thomson & Hall, 2017), particularly regarding the influence and reach of external relational entanglements over time. Being present in the school and its surrounds for this duration also meant I could begin to appreciate the porosity of my chosen school site more fully in terms of how various external relationships entangled with the everyday rhythms of the school, and how the school's seemingly isolated daily pattern of rituals, practises, processes, beliefs, and expectations were in themselves shaped by these external relational entanglements. In this sense, the present study's application of multiple place-based methods and its determination to collect multiple sources of both found and researcher generated data opened up spaces to explore how 'struggles over power are conducted' (Selwyn et al., 2018, p.14). As such the present study can be understood as 'feminist in its desire to create and collect materials highlighting gaps and silences' (McKnight, 2018, p.223). For this reason, I am also purposeful in my avoidance of 'the logics of quantification [that] leave out lots of interesting and potentially consequential things about the phenomenon … [leading to] stripped-down portrayals' (Freebody, 2003, p.35).

Given this study is concerned to explore 'how and why-type research questions' wherein I have 'little or no control over events, and when activities of interests are observable in real-life context' (Jung, 2014), this study satisfies the criteria of an ethnographic case-study. Accordingly, it draws from key features attached to multifaceted understandings of ethnography as each applies to social research (Hammersley & Atkinson, 1983; Hammersley, 2018). These include collecting 'unstructured' data in the school's natural setting and closely observing the site in a range of ways through multiple site observations; and collecting and generating a variety of data types, including documenting in situ what 'actually goes on', noting the significance staff give to material objects and the nature of social structures and relations; and using explanations and descriptions to analyse and interpret the

meaning of generated data rather than applying a quantitative statistical approach. Each of these aspects develops what Clifford Geertz (1973) refers to as a 'thick description' (p.6) of a research site which consists of both a 'thin description' of facts *and* how complex processes are 'lived together and in contradiction' (Skeggs, 1999, p.48 – emphasis mine).

Drawing inspiration from the thick place-based ethnographic research designs used by Sara Lawrence-Lightfoot(1983), Jan Nespor (1997), Torin Monahan(2005), and the place-based methods advice offered by Pat Thomson and Christine Hall (2017), the present study's research design aims to produce a particularised, granular understanding of Greenfield College wherein the school itself – as advocated by scholars in Chapter 2 and Chapter 3 – is considered neither a neutral background nor an island with impenetrable boundaries. Accordingly, my application of a range of data collection methods to generate multiple data sets works to develop a 'more complete exploration of a given situation, addressing all its levels and dimensions' (Connell, 2013b), much like 'pieces to a puzzle—the more pieces that the researcher has collected and arranged, the greater the ability to provide a deeper understanding of the case being studied' (Baxter & Jack, 2008, p.554).

Also built into the design of the present study is the use of ethnographic vignettes. These are used to preface observations of Year 7, Year 8, Year 9 and Year 10 Maker technology classes in Chapter 7. Designed to illustrate the 'nexus of concepts and relationships' which the 'surrounding text then tease[s] out' (Jarzabkowski & Bednarek, 2014, p.8), each vignette was created by 'slip[ping] in and out of different ways of presenting data' (p.7) to provide the reader with a sense of 'what it was like to be *there* in the field' (p.8 – emphasis in the original), immersed in the messy everyday reality of my chosen school site.

4.3 Research Questions

Given the aim of this study is to explore what the introduction of Maker technologies in schools tells us about the gendered nature of contemporary schools and schooling more generally, three specific research questions guide the empirical activities of this study:

1. How did Maker technologies – and the idea of Making – find a place in the school?
2. How did the school's institutional and pedagogic conditions influence the use of Maker technologies in the school?
3. How did understandings of gender shape girls' engagement with Maker technologies in the school?

4.4 Data Sources and Collection

Data was generated for this study through interviews, observations, walking, journaling, archival research (hard-copy and digital), voice annotations, videos, and photography. Each dataset was distinguished by tagging in the first instance as either 'found' or 'researcher produced'. Thereafter, when engaged in analysis, 'found' or 'researcher-generated' texts', I engaged in discerning the 'official and unofficial … at work in the texts', particularly in terms of how 'flows of information from other schools, as well as regional, national, and global sources, enter[ed] the school' (Thomson & Hall, 2017). Here as per Thomson and Hall's (2017) advice, I carefully considered how the datasets (transformed to texts) 'come to be as they are, how they produce and reproduce social relations, and what work these texts do within and beyond the school' (p.203).

Falling under the banner of found sources of data are my collections of newsletters, school yearbooks, displays, Principal letters to parents, reports, strategic plans, and websites found in school archives – both digital and hardcopy, written and visual – all of which provided a helpful lens through which to examine how Greenfield College presents itself to the public, projects its ethos and markets its priorities and values. Useful here too are the various administrative texts it routinely published to present their operations and governance. These include the school's leadership organisation charts, staff lists, timetables, room allocations, budget projections and expenditure lists, meeting rosters, agendas, and minutes, all of which bear testament to the administrative power and production dynamics embedded within a school's 'local-national frames and interactions, hierarchies, movements, territories and boundaries, and groupings' (Thomson & Hall, 2017, p.205). Moreover, because the significance of many of these found written and visual texts rests as much in where each is published, for whom and for what purpose, I asked questions about the purpose each text serves, how each text supports or contradicts a particular view or way of thinking about the school, and how (and why) students, parents, teachers, leaders, or visitors are positioned to read these visual or written texts.

Adding to the mix of data sources used in this study were 'researcher-generated' texts produced every time an interview was conducting then transcribed, fieldwork notes that were scribbled down or voice recorded (then transcribed), photographs or videos were taken inside research sites, and as is the case for this study – the descriptive ethnographic vignettes that were written to help create a sense of immediacy to immerse the reader more deeply in the place that is the school research site. In this study, significantly valued too are the hundreds of researcher-generated photographs and

videos that were taken to create a visual textual record of the multiple layers of my research experiences, particularly of place.

My use of a photography (using my smartphone) as a means of collecting visual datasets served as a visual reminder of my observations. Here as each visual text was generated, awareness was maintained that I was applying my personal social, cultural and political lens, and thus what I was capturing did not present a 'true' depiction of place as it may be 'read' differently by others. Further, to protect the anonymity of my research subjects, I also tried to frame my photographs to not include identifiable aspects of Greenfield College or its occupants; when this was unavoidable, I ensured such aspects were pixelated. Irrespective, the visual texts generated of place work as a marker of a moment in time in the present study when an activity, interaction, instruction, material, or spatial relation signified either a 'one-off' or 'regular' experience that accrued 'marks left behind of bodies moving, acting, and interacting' (Thomson & Hall, 2017, p.193). In this sense, my progressive generation of photographic image texts, along with my scribbled fieldwork journal notes and transcribed voice memos, worked together to: first, thicken my in-depth place record of Greenfield College's neighbourhood, internal and external buildings, in-between-places, storage and display places, teaching and learning artefacts, student work and significant places or materials; second, make visible previously unseen (or unconsidered) places where social, material, spatial and therefore political relations of gender may be influencing girls' engagement with Maker technologies; and last, surface potential sites to locate feminist interventions.

4.5 Research Procedure and Methods

Thomson and Hall (2017) argue that the complex nature of schools means that it takes 'more than one, two or even three ways to get to know it as a place'. Thus, this study uses four phases of inquiry to collect found and researcher-generated data sets, with the aim of producing a large corpus of empirical data that bears witness to how Maker technologies – and the idea of Making – came to find a place in the school. From this, attention turned to how various understandings of gender are articulated in and through the school's internal structures, places, activities, narratives, practises, attitudes and belief systems, and how these understandings entangle with – and are informed by - external understandings of gender articulated in education policy.

These four phases - (I) Exploring the school surrounds; (II) Reading the school; (III) Interviews; and (IV) Observations – provide opportunities to collect and generate multiple data sources which

together offer an 'eagle's eye view' of Greenfield College that constitutes both its 'horizon' and 'life between the blades of grass' (Thomson & Hall, 2017, p.13). Of critical importance here is that creating these four spaces to collect and generate multiple datasets also made room to discern how the school's 'local nuances of historic, social, economic, cultural, and political frames' (Lipman, 1998, pp.11-13) shape and influence girls' engagement with Maker technologies in the school (see Table 4.1).

Phase I - Exploring the school's surrounds

Phase I of this study used the Australian Bureau of Statistics (ABS) website (www.abs.gov.au) to locate historic patterns of occupational and unemployment data, profiles of race, ethnicity, age and religion, and the highest education levels of household members residing in the local neighbourhood surrounding Greenfield College. This information was buttressed by archives found on the local Council's website which were surveyed off site to develop an understanding of significant cultural events, landmarks, and associations. Similarly, online archives of local newspapers, local business associations, and community groups found online or at the local library were scrutinised to discern the key issues pertaining to the local neighbourhood of Greenfield College over the period 1960-2018, and particularly for instances when these latter sources made mention of the school.

Informed by desktop research, I approached my physical engagement with Greenfield College's local neighbourhood with an already partially developed sense of the mix of homeowner and rental properties, and the socio-economic and cultural profile of residents. Thus, when tracing by foot a student's daily route to and from the school via the local shopping centre on their way to or from the local train station or local bus routes, noted were the wares and services provided by shops and other amenities along the way. This included local business signage as these material signifiers provided insights into the cultural and socio-economic neighbourhood milieu in which Greenfield College was positioned.

Walking the streets of the local neighbourhood immediately surrounding the school and mapping out the numerous material characteristics of nearby and adjacent streets, involved taking photographs which were briefly described using voice memos at the time of capturing, some of which I further explained by taking notes in my fieldwork notebook. Here images of the built environment include the frontage of houses, front yards, footpaths, fences, roads, streetscapes, vehicles, local

council reserves surrounding and/or close by the school, always Making notes (voice and handwritten) of the type

PHASE I – EXPLORING THE SCHOOL SURROUNDS **PHASE II – DOCUMENTING & READING THE SCHOOL**	**Historical** Written & Visual Texts	○ Yearbooks (1956-2018) ○ Photographs (School Council, Special Events, Buildings, Teachers – 1960s/80s) ○ Accountability Documents (Agenda, Minutes, Publicity) ○ Annual Reports to the School Community; Charter reports ○ Annual Implementation plans (AIP – 3 years); School Strategic Plans (1 year) ○ Budget (Charter, Innovations Fund) ○ Internal Meeting documents, Minutes, Policies, working party papers. ○ Innovation Grant Applications ○ Council Minutes and supporting documents ○ Parent, Student, Teacher Opinion Surveys ○ School Level Reports to staff ○ Senior School destination data, results ○ Community Partnerships and Programs ○ Website Archives (2001-2017)
	Contemporary Written & Visual Texts	○ School Operations and Administration (Marketing, Prospectus, Website E-Docs, College Schedule, Facilities, House program, Sub school Reports, Parent Newsletters, Staff Handbooks, School Policies x 38) ○ Teaching & Learning (Instructional pedagogical model, curriculum, assessment, unit overviews, teacher resources (textbooks, websites), student attitude to class surveys) ○ Network & Technical Support (Network mapping, DET Policy, Protocols) ○ Photographs (Buildings, offices, admin, corridors, display boards, classroom locations, grounds, equipment, computer labs, storage, renovated classrooms)
PHASE III **INTERVIEWS**	**19 hours** Semi-Structured Interviews Duration (45-60 mins)	**19 Staff in Total** ○ 1 x Principal & 1 x Assistant Principal (Student Engagement & School Operations) ○ 4 x Teacher Leader (Curriculum & Data Management, Teaching & Learning, School Coordinator, Staff Development) ○ 3 x Teacher Leader – Learning Area Coordinator (Library Services, The Arts, Digital Technologies) ○ 7 x Classroom teachers (2 x Year 7 Coding; 2 x Year 8 Coding; 2 x Year 9 Electronics; 1 x Year 10 Robotics) ○ 3 x Technical Support (ICT Manager, Specialist Technician, Local Support Officer)
PHASE IV **OBSERVATIONS**	**105 hours** 7 Classes in total	**Junior School** ○ 2 x Year 7 Coding (Term based 'compulsory' Elective – 2 x 55-minute lessons pw) ○ 2 x Year 8 Coding (Term based 'compulsory' Elective – 2 x 55-minute lessons pw) **Middle School** ○ 2 x Year 9 Electronics (Semester based Elective – 3 x 55-minute lessons per pw) ○ 1 x Year 10 Robotics (Semester based Elective – 3 x 55-minute lessons pw) *pw = per week

Table 4. 1 Research Phase, Methods and Data Set Summary

and condition of each material aspect, the placement and wording of – for example - real estate 'To Rent' or 'For Sale' advertising boards. This phase of my research yielded an extremely rich corpus of

primary and secondary source visual and written datasets, including descriptive fieldwork notes, hundreds of smartphone captured voice memos, photographs, and videos, including text messages and emails I sent to myself to keep uppermost in my mind particularly significant photographs or descriptions, many of which are now included in this thesis.

Phase II – Documenting and reading the school

Commenced in the early weeks of this study once permission was granted by the Ethics department of Monash University and the Victorian Department of Education (DET), and the Principal of Greenfield College, I entered the school to further document and 'read' the school (Phase II – Reading the School) as place prior to undertaking Phase III - Interviews and Phase IV - Classroom Observations. Here, the Principal immediately provided unrestricted access to a substantive collection of archived documents (hardcopy and digital) located in the library and on the school's online CMS (content management system). Both were found to contain a significant library of archived materials, including copies of hand-typed documents and photographs dating as far back to the 1950s.

As each document was closely examined, descriptions were added to my fieldwork notebook or via voice recordings, both the rudimentary information pertaining to what I was examining, where it was found and my initial thoughts about each source's relevance – and indeed significance – to the present study. Of particular interest here were photographs or documents that further thickened my contextual understanding of Greenfield College – particularly aspects regarding equal opportunity policies, external relationships, the introduction of educational technologies more generally, and Maker technologies specifically. Regarding documents related to equal opportunity, my attention was drawn to moments in written and/or visual texts 'where various authoritative discourses fused with institutional power clash[es]' (McKnight et al, 2020, p.1196).

Around much the same time, also scrutinised were other readily available publications produced by the school for public consumption. This included articulations of the school's vision and profile as located on the Australian government's *My School* aggregator website (https://www.myschool.edu.au). Here, the *My School* webpage for Greenfield College provided both historic and contemporary data pertaining to the number of teaching and non-teaching staff working in the school, student numbers and profile, including differentiation by sex, income sources, NAPLAN test results for Year 7 and Year 9 students as compared to 'like' schools and Australian schools more generally, school completion data for senior students. To extend the information found through the

My School record, the school's Year 12 external examination performance scores for each senior subject taught in the school dating back to 2012 were located using the Victorian government's Victorian Curriculum and Assessment Authority website (VCAA). Adding another layer of interest were the archives of state and local newspaper articles and/or photographs that reported on student and school 'high performance success' as judged by Greenfield College's median score for Year 12 (VCE) results ranked against other Victorian schools and individual student achievements.

Thereafter, my attention turned to the digital and hardcopy archives of school generated reports, again written by the school for the local community's consumption. This included archived documents written to support School Council meetings for the past decade, Annual Implementation Plans, School Strategic Plans, School Charter and Innovation reports, School Newsletters – both hardcopy and digital – and School Prospectus Publications (hardcopy and digital) dating back to the 2000s. When surveying the school's website, I used *Wayback Machine – Internet Archive* to survey the school's website offerings over the period 2001-2018. This allowed me to exhume an evolving picture of the school's description of itself, its vision statements, changes to the design to the school's logo, annual reports, curriculum subject offerings, policies and priorities, Principal newsletters, leadership team structures, special programs, international students, career pathways, and external provider, reports and photographs of visits from significant public figures, and more general notices, including uniform supplies and student learning resources. Here attention was paid to the images chosen to represent the school across all publications, especially regarding how images were chosen to present a particular view of students, teachers, leaders, or the school more generally. Of interest too was how students, teachers and leaders appearing in photographs were framed, with whom, against what background, and how the school increasingly sought to market and position itself as having a point of difference from other education providers in the local area.

This phase of 'reading the school' also sought opportunities to determine the school's various external 'relational entanglements' (Thomson & Hall, 2017). Examined here were internal publications archived and tabled for leadership team meetings (including minutes), documents outlining local school responses to an evolving suite of state education policies from the mid-1980s, corporate business partnership agreements, external university pedagogue visits, former Principal buddy consultant programs, professional learning sessions run by external private and university providers to support and facilitate teacher improvements in teaching and learning, data literacy, pedagogy, assessment. Other external relational entanglements were found via their inclusion in

school newsletters, posters, leaflets, and especially the school's website archives which surfaced an increasing array of outsourced professional relationship, partnership, and sponsorship agreements. As the years progressed, this list of relational entanglements grew, with those offering 'value-add benefits' to help students achieve 'success' dominating, followed by external contracted services of student learning consultants, coaches, specialist examiners, local business sponsorships and the delivery of student mental health programs by not-for-profit organisations and other individual external psychological and physical health providers (see Chapter 5).

Regarding the external built environment, a map found in the school's staffroom was followed which outlined the school's main buildings. Again, hundreds of photographs, recorded voice memos, drawings, and written descriptions of the school's internal and external surrounds were generated. Key external features were noted, including how the school demarcated itself from its local neighbourhood through fences, signage, car parking, the upkeep of buildings and landscaped areas for student passive and active use, security systems and particularly the attention paid to creating the school's front façade, including the type and upkeep of plantings, fences, and pavements.

For the internal built environment, a photographic journal was similarly created, again annotated using voice recordings and written fieldwork notes. Key focus areas included the front office area, the location of staff and leadership areas, the location and upkeep of specialised and general classrooms, including the furniture, whiteboard, and storage arrangements within each. Areas signed as forbidden to students, or directing expectations of student behaviours and attendance, display boards in classrooms, corridors, and stairwells of the multi-story building were photographed. Noted too was the colour, condition and style of doors, walls, and the positioning of windows, air conditioning and classroom heating provisions and other fixtures and fittings.

Phase III – Interviews

Nineteen adult staff drawn from across the school's organisational structure accepted my invitation to participate in semi-structured interviews which ran, on average, between 45 – 60 minutes. All interviews were held on school premises prior to classroom observations occurring and after I had begun to sort my corpus of empirical data derived from Phase I and Phase II. This ensured that prior to each interview taking place, I had already begun to 'inhabit' (Thomson & Hall, 2017) the school's historic, social, economic, and political context which, in turn, helped me make sense of, and seek

further clarification about, key moments, behaviours, practices, or processes that each interview staff discussed.

Semi-structured interviews were chosen to provide staff with an opportunity to pursue self-chosen lines of thought which may be prompted by pre-determined questions, thus leaving the study open to receiving unanticipated lines of information. Following this approach also meant the staff and myself could modify the order and wording of questions, with both also being provisioned a significant space to furnish additional comments should we so choose. The focus of interview questions was provided to staff at the same time they received - and signed - the informed consent forms which were distributed to staff at the beginning of the present's study's fieldwork. Here research questions were aligned to a set of pre-determined topics, with the aim of generating multiple accounts of the same phenomena from staff who occupied different positions in the organisational structure of the school. Furthermore, all staff were made fully aware how the interview would be undertaken, and how staff identities would be protected by deidentifying staff names using pseudonyms.

The nine topics used to focus each interview included:

1. perceptions on the nature of Maker technologies.
2. reasons for bringing Maker technologies into the school.
3. how the use of Maker technologies in the school fitted with the school's broader vision.
4. budget processes to purchase Maker technologies.
5. places where Maker technologies are used and how these support or limit Maker technology use.
6. how Maker technologies are supported through technical support, programming, and scope for future use.
7. teacher expertise, pedagogical approaches, resources, professional learning, and external support.
8. student engagement, experiences, learning, assessment, link with STEM subjects and career pathways, and particularly girls' engagement.
9. perceived benefits and challenges of using Maker technologies in the school.

Each interview was recorded using my smartphone, commencing with the staff outlining their position, years teaching at the school, including (if relevant) years teaching with Maker technologies. Once complete, each of the nineteen interviews was transcribed within the week immediately following the completion of each interview. At this time, interview identities were anonymised, and key insights tagged broadly in accordance with their relevance to my three research questions. Moreover, many staff members brought to their interviews additional documents, photographs, or

copies of digital files to support or add to their interview responses. Other staff provided access to – or copies thereof – documents or photographs to support their interview discussion points after their interview. These materials were added to my burgeoning collection of data as generated from Phase I and Phase II of the present study.

Phase IV – Classroom observations

The last phase of fieldwork involved undertaking classroom observations of seven (7) classroom teachers using Maker technologies in their timetabled classes over a ten-week period in Term 4. In sum, just over 130 hours of classroom observations were undertaken, which included students engaging with Maker technologies in two term-based Coding electives in Years 7, two term-based Coding electives in Years 8, two Year 9 Electronics electives and one class of Year 10 Robotics. In each instance, a non-participant peripheral member observation method was adopted which involved observing the spaces, how the teacher and all students engaged with Maker technologies, how girls more specifically engaged with Maker technologies, all the while Making a conscious effort to stay separate from the action I was observing. This non-participant approach was chosen primarily to develop a more nuanced appreciation of – and test staff perceptions and beliefs about - the use, limitations, and benefits of students using Maker technologies in the school, particularly by girls.

For each class, observations commenced by watching and listening to students in the five-ten minutes prior to their teacher's arrival as they gathered outside the locked door of their designated classrooms. Once inside, I would locate myself towards the back or side of the room and draw up a student seating plan for each observed lesson. Soon after each lesson commenced, I would begin to quietly shift my observation position over the course of the lesson and take non-identifying photographs of teaching and learning artefacts, recording my observations and experiences in detailed fieldwork notes.

In each class, I focused on the general dynamic of the class, the teacher's pedagogy and choice of teaching and learning materials in the class, the teacher's interactions with students, and students' engagement with Maker technologies, particularly by girls. In so doing, I remained cognisant of the need to do more than regard the 'material world as mere backdrop' in each classroom and refuse the option to look upon 'students as inert foils to the performances of pedagogical mastery' (McKnight, 2016, p.203). At the conclusion of each lesson, I therefore caught up briefly with each classroom teacher wherein the teacher would either offer a spontaneous debrief of his or her

perspective of what had just occurred in the lesson, or chat about a significant moment, or offer a reflective insight of a preceding class or something similar and/or I would ask clarifying questions of what I had observed either in that lesson or one I had attended previously. These informal conversations which usually amounted to less than 5 minutes added additional insights which are woven into the Observation chapters (Chapter 7-8).

For each observation, the fieldwork notetaking advice of Tim Cresswell (2004) was followed. This involved writing, drawing and/or recording descriptive field notes to document the actual environment I was observing - including the space, materials, activities, and people – and noting my thoughts, ideas, and reflections about what I was observing. At the conclusion of each observed class and my debriefing conversation with each classroom teacher, I also voice recorded my reflections on how the classes I had just observed fitted into or added another layer of insight to the broader patterning of institutional or pedagogic conditions, relational entanglements, or gender that I was progressively discerning by engaging with my multiple datasets as generated in each of the four phases of the present study; particularly those that appeared to be influencing girls' engagement with Maker technologies.

Student Focus Groups

Prior to commencing this project, I had planned to run small focus group discussion with up to five girls per observed class at the conclusion of my observation period. Accordingly, in the planning stage I sought - and gained - Ethics permission from both Monash University and the Victorian Department of Education (DET) to do so. However, from the outset the Principal of Greenfield College expressed concerns about this aspect of my fieldwork due to all students in the school also being required to complete similar focus group student feedback sessions and surveys to gather data on teacher performance in each subject they undertook in Term 4. For this reason, I elected not to proceed with my planned focus groups as a research method for this study. This decision was immediately communicated to the Principal – confirmed in writing – on the day this discussion took place.

4.6 Introducing Greenfield College

From 2016, the Australian government provided considerable financial support to Australian government schools to use the conduit of Maker technologies to expand student interest and diversify student participation in STEM subjects and career pathways. This significant policy initiative particularly sought to encourage girls, students from non-dominant cultural groups, and students

living in socio-economically disadvantaged local neighbourhoods to engage with STEM subjects and consider STEM career pathways in their senior years of schooling. In the year this present study was undertaken, all Victorian government schools were also mandated to begin delivering the state-wide Victorian Curriculum in Digital Technologies. Accordingly, this study sought to locate a Year 7-12 (11-18 years old) co-educational government school whose student population matched the characteristics described above.

To find a suitable government school, I first visited the Australian government's *My School* website (https://www.myschool.edu.au/). As already mentioned, this provided trend information about individual school sectors, individual schools, year levels, location, staff, student body socio-economic profile, student enrolments according to sex and student cultural backgrounds. This information was then cross-referenced using the social, economic, and demographic geographic variables made available on the Community Profile page of the Australian Bureau of Statistics (ABS) (abs.gov.au) website. Four (4) coeducational government schools were short-listed as potential research sites. Thereafter, desktop research was used to determine if each was using Maker technologies in Years 7-10 as part of their everyday formal curriculum. This reduced my short-list to three. Once Ethics approval was obtained, email contact was made with each Principal of the three short-listed schools to ascertain interest in participating in this study. Only one of the three schools agreed.

Under the pseudonym of 'Greenfield College' (to protect the anonymity of the school, teachers, and student staff of this study as per Monash University and DET Ethics requirements), the site used for this study is a Year 7-12 (students aged 11-18) co-educational government school located in a residential-only area located less than 20 kilometres to the northwest of the Central Business District of Melbourne, Victoria, Australia. Greenfield College was deemed to be a suitable site for this study for five reasons which I briefly outline below:

Student sex and cultural profile

Almost seven decades ago, Greenfield College's first student population consisted of 126 students consisting of 71 girls and 55 boys - mostly of European, Russian, or Slavic migrant backgrounds. In the years spanning 2000s – 2010s, the student population of the school progressively shifted to include students from Vietnamese, African, Sudanese, Ethiopian, Solomon Islander and Fijian migrant and

refugee families, with 1% of students identifying as Indigenous. In the year this study was conducted (2018), a total of 1453 students were enrolled in Greenfield College, 728 female and 725 male students, with just over half these students speaking a language other than English at home. No Indigenous students were enrolled at the College at this time.

Student socio-economic disadvantage profile

Greenfield College is situated in a socio-economically disadvantaged neighbourhood with high unemployment. Most families rent their homes. Described as a dormitory suburb due to residents needing to travel to work outside the suburb either by car or public transport, there are few local employment opportunities. Since the 1990s, socio-economic disadvantage related to high unemployment has been exacerbated by the closure of many of the suburb's small commercial and light industrial businesses that had otherwise successfully operated in the three decades spanning the 1970s -1990s. From the 2000s, local employment opportunities have been restricted to the suburb's major assets which include several primary and secondary schools, the local town shopping centre, two major supermarkets, several well- known fast-food restaurants, a large district hospital and the suburb's leisure centre.

Use of Maker technologies

Greenfield College informally introduced Maker technologies to students in a lunchtime Maker Club run once per week in 2016, and to formally timetabled classes of Year 7 and Year 8 students for the first time in 2018 to fulfil the State government's requirement for all Victorian schools to deliver the new Digital Technologies curriculum mandated for implementation at the beginning of 2018. Student elective subjects for electronics and robotics (rebadged as 'Maker' in 2018) had been part of the broader student elective program in the schools since 2006.

High Performance, Successful, School of Choice

The impact of neo-liberal education reform policies outlined in Chapter 2 and Chapter 3, particularly those features aligned to the decentralisation of schools from the 1980s, also point to the suitability of Greenfield College as a site for this study. Historic archives of school newsletters, prospectuses discerned using desktop research revealed that from at least the 2000s, Greenfield College had begun to actively market itself as a 'Globally Connected' 'High Performing', 'Successful', 'Academic'

government school of 'Choice' for local families – particularly to families of high-ability students located within and outside the school's set enrolment zone, and to international students. Furthermore, the school was found to particularly focus on promoting girls' academic successes on its website, and through the local media, corporate partnerships and other digital marketing publications found on archived copies of the school's website from 2001-2018.

External Partnerships

Also occurring from the 2000s on the school's website was a growing acknowledgement of high-profile corporate, local business, local council, social enterprise, for-profit educational enterprises, individual consultants, and higher education partners, and in other documents written for public consumption. Internal documents later found in digital folders entitled 'Community partnerships and promotions' made clear that each external relationship was designed to help the school consolidate its 'brand' as a 'high-achieving', 'high performing', 'successful' school for Year 12 graduates, particularly girls.

4.7 Staff Selection

The Principal of Greenfield College was contacted first by via email using an email address available on the public domain to ascertain interest in participating in this research study. Attached to this email were the Explanatory Statements and Consent forms that the Principal passed on to each of the 21 staff whom she identified as having a direct or indirect association with Maker technologies being brought into, used, and maintained in Greenfield College. Each adult staff member who subsequently expressed an interest (and chose) to in participate in this study directly returned the consent form to me either in person or via email. By signing these informed consent forms - approved by the Ethics Committee of Monash University and the Victorian government Department of Education (DET) - staff provided their permission for me to audio record interviews (using my smartphone), take notes in interviews and observations, make use of artefacts brought to the interview, and publish anonymised results in this dissertation and in other scholarly settings.

To ensure the thickest possible description was developed of how Maker technologies were perceived as (and were) being used in Greenfield College, the school's institutional and pedagogic conditions, and how various understandings of gender lived in the school, this study sought to engage staff drawn from across the whole school organisation. In sum, nineteen (19) staff drawn from top

to bottom of the organisation agreed to participate. Citing reasons related to only just joining the school community at the time this study was held, the new Assistant Principal (Wellbeing) and newly appointed Assistant Principal (Teaching & Learning) declined the invitation to participate. Those who agreed included: the Principal, the Assistant Principal (Student Engagement and School Operations), four Leading Teachers representing all four school improvement portfolios (Curriculum & Data Management, Teaching & Learning, School-Coordinator, Staff Development), three teachers with the Higher Duties responsibility of a Learning Area coordination (Library Services, The Arts and Digital Technologies), four junior school (Years 7-8) Maker technology classroom teachers, three middle years Maker technology classroom teachers (Years 9-10) and three Technical support staff, including the ICT Manager.

4.8 Data Analysis

Kept foremost in my mind whilst analysing the data sets generated by the present study was Jan Nespor's (1993) view that schools are best viewed as a messy 'knot in a web of practices that stretch into complex systems beginning and ending outside the school' (Nespor, 1993, p.xiii) and Thomson and Hall's (2017) notion that schools are 'thrown together through ongoing, active processes of arrival, departure, disruption, and intervention' (Thomson & Hall, 2017, p.15). For this reason, the sense-making processes used in the present study were both iterative and holistic each time raw datasets were (re)visited. This meant from the very beginning, no attempt was made to produce an all-encompassing explanation of the spatial, material, or structural contingencies which influence girls' engagement with Maker technologies in secondary schools. Rather, I remained cognisant of my aim to create a space for the emergence of a different kind of understanding.

Furthermore, the methods adopted for data analysis were neither a 'mopping-up activity at the end of the research project' nor a 'social act of telling'. Rather, from the very beginning, a 'writing analysis' approach was used wherein I regularly journaled (or voice recorded) my thoughts about the emerging patterns, grouping, categories and 'nuggets' of understanding found by scrutinising the present study's datasets. Significant here were the occasions wherein I immerged myself in the 'in-between space' of the intertwined '*writing process* and the *writing product*' (Richardson, 2000, p.930 – emphasis in original). In this sense, the data analysis process of the present study was a continuous iterative process of turning notes and reflections about found and researcher-generated texts into transcripts, then thematic clarifications, then into this thesis submission.

The approach to data analysis and interpretation applied in the present study is best described as 'thematizing' (Thomson & Hall, 2017, p.198). Analogous to Tim Cresswell's (2007) 'data spiral' (p.150) metaphor, my aforementioned 'writing analysis' also spoke to Yin's (2009) suggestion that researchers 'play with [their] data' (p.129) by organising, adjusting, assembling it, and reassembling it into flowcharts, graphic organisers, and sorting chronologically to ensure the story it seeks to tell can most freely emerge (Justice, 2016).

For the present study, the preliminary sense making steps undertaken necessitated first the selection of a mechanism to reduce the huge corpus of collected datasets. To assist, research questions and theory chapters were reread to sharpen the focus of my data readings. This enabled me to 'let go of the unimportant information that [did] not correspond with the aim of the study' (Bengtsson, 2016, p.12). Thereafter, the process undertaken entailed: first, getting very familiar with my data; second, establishing data patterns and groupings by ordering, categorizing and connecting isolated data 'nuggets'; and third, making sense of newly forged patterns and groupings by calling on conceptual or theoretical framings that then turned data into results (p.199). At this point, a visual matrix of organisational, substantive, and theoretical categories (Maxwell, 2005) was created wherein the top row of my matrix included several large themes, under which were located my sub-categories and summaries which I devised from the theoretical insights discussed in Chapter 2 and Chapter 3. Significantly, whilst applying theory to 'clarify, explain, elaborate and draw out possible implications' from my datasets I also remained cognisant of the need to also 'locate myself in the frame' (Thomson & Hall, 2017).

The final stage of analysis used in the present study further scrutinised my emerging understanding of Greenfield College by 'thinking institutionally' (Connell, 2002); particularly about how gender relations infused the school's ethos, institutional and pedagogic conditions. Here my aim was to lift the spatial veil otherwise rendering invisible the gendered substructures of Greenfield College's organisation's gender regime. This was achieved by applying Raewyn Connell's four-dimensional conceptualisation of gender relations (power, production, emotion and symbolic) to my now thick matrix of institutional understandings. To do so, the school's context, ethos, institutional conditions, and relational entanglements were re-read through the lens of Connell's four-dimensions of gender relations to surface how gender operated in relation to:

1. variable structures of power located within and external to a school's immediate context.

2. relations of production and consumption, including access, allocation, and categorisation of individuals within an organisation's hierarchy.
3. power exercised over individuals and a collective in the form of control, authority, and force.
4. emotions (positive and negative) expressed through relationships and/or attachments of people and groups organised along gender lines.
5. symbolism as expressed through cultural expressions, artifacts, and social practices.
6. social arrangements, social practices, and every day activities.
7. school structures that socially defined what is possible and what is not - including who has access and who is excluded.

4.9 Researcher reflexivity

There are four participation levels for researchers engaging in qualitative research studies: complete-member-researcher, active-member-researcher, peripheral-member-researcher, and. complete-observer (Jung, 2014, p.5). In this study, I took on the role of a peripheral member-researcher wherein the insiders' perspectives are valued and closely involved with the research setting whilst not otherwise participating in actual activities or taking on other responsibilities.

Yet, in doing so I also remained cognisant of the need to be reflexive as a key attribute of applying ethnographic and feminist theoretical perspectives is the awareness that 'any researcher's critical consciousness is constrained by the limits of their knowledge, culture and experience, and by their personal skills, powers of empathy and political openness to silences and exclusion' (Ramazanoglu & Holland, 2002, p.119). This, combined with the ethnographic understanding that researchers 'have no way of standing outside [their own social location] to reach some objective and neutral vantage point from which to view things 'as they really are' (Denscombe, 2014, p.88), points to the need for me reflect upon how my own social location influences the choices, decisions, and interpretations made whilst engaged in this research process.

I have two decades experience working as a Geography and Global Politics teacher, and a decade working as a senior school leader in government coeducational secondary schools, with responsibilities including leading the implementation of digital technologies across whole school systems, and the professional learning of large cohorts of teachers and support staff. When attending secondary school, I was one of only two female students in a cohort of more than 130 senior students in a coeducational government school who chose to study only STEM subjects in my senior years.

Both sets of personal and professional experiences contribute to the perceptions I now hold of how students and schools more generally function.

Furthermore, when working as the only female in a senior leadership team of five principal class leaders, I also found myself habitually confronted by my colleagues' view that it was an inherent lack of confidence that led to female students' unwillingness to take up computer science subjects and female teachers' seeming reluctance to use digital technologies in their classrooms. Herein, the prevalent view was that both problems could easily be resolved by hiring more female computer science teachers to act as role models for girls and sending the seemingly fearful and reluctant female teachers off to complete external professional development courses to build up their resilience. When neither solution eventuated in change for either girls or female teachers, I was not surprised. However, on these occasions I also soon found myself frustrated by my male colleagues' decision to set aside both aforementioned 'problems 'of girls/women engagement with technologies in the 'too hard' basket for someone else to deal with in the future rather than seek out alternative explanations and interventions that made lead to solutions.

Consequently, one of my aims in this study is informed by my desire to generate new knowledge and challenge the perpetuation of these deterministic, instrumental explanations; albeit many years after these events occurred. Thus, I readily acknowledge that my hope to broker new ways of understanding girls' and teachers' engagement with Maker technologies is also shaped by my own positionality and that my subjective values - formed through - and by - my past educative and professional experiences - may indeed influence not only what my eyes and ears were drawn to when documenting the social context of my case-study school, but also my interpretations of what I observed and how I analysed the data sets generated by this study's empirical inquiries.

4.10 Ethics

In a procedural sense, this research study required Ethics Approval from Monash University and the Victorian State Government Department of Education (DET) (Approval was granted by Monash University Human Research Ethics Committee on 21 August 2018 (Project ID: 14260) then on 12 October 2018 by DET (See Appendix I). Here, the consent of students and teachers observed using Maker technologies within scheduled core or elective classes was provided by virtue of the school Principal agreeing to participate in this research project.

Furthermore, because this thesis is feminist in both focus and orientation, it also integrates a feminist ethic of care and relationship into its conduct of research which is grounded in the 'subjective, the particular and the relative' (Preissle, 2007, p.528) of people, places and contexts. Emerging from the work of early feminist scholars including Carol Gilligan (1982) and Nel Noddings (1984), feminist scholars over the past four decades have progressively placed a greater emphasis on researcher care, relationships, and responsibility when considering qualitative research ethics (Edwards & Mauthner, 2002). Heeding Noddings' (1984) call for more empathetic relational research responses and Jane Tronto's (1993, 2006) articulation of four 'phases of care' which call for 'taking care of' (responsibility), 'caring about' (attentiveness), 'care-giving' (competency) and 'care-receiving'(responsiveness), this study applies Rosalind Edwards and Melanie Mauthner's (2012) feminist ethics of care research practice guidelines. Doing so ensures that when engaged in ethnographic processes of 'deliberating dilemmas, choosing from alternative courses of action, and being accountable for the course of action that [I] ultimately decide[d] to pursue' (p.25), I remain cognisant of the need to be attentive to the interests and inter-relational needs of all persons involved in my study, their individual (and relational) social and personal locations and contexts, and my own need to be self-reflexive when engaging with each and every aspect – people, context and location – related to my project's 'conceptualization and design, data gathering and analysis, and report' (p.18).

Chapter 5. FINDINGS I – Greenfield College the place

This chapter does not focus on maker technologies nor their use in Greenfield College. Rather, its purpose is to help us develop an understanding of Greenfield College more fully as a site for exploring Maker education in terms of gender equity. To this end, the chapter begins by exploring the composition of the school as it is presented on paper, and then shifts to offering a thick description of how the school was physically encountered in person. Here, the reader is taken on a journey that explores the local neighbourhood of the school, then the school's grounds, physical buildings, and internal spaces. To enrich this initial mapping of place, the chapter ends by outlining the various external organisations, groups and individuals entangling with the school, as discovered by rooting through the school's digital and hard-copy archives. Each aspect works in concert to build a more thorough profile of Greenfield College 'the place' that is in keeping with Thomson and Hall's (2017) 'eagle's eye view' which 'keep[s] one eye on the horizon and the other focused on life between the blades of grass' (p.13).

5.1 The official composition of Greenfield College

Throughout the 1980s and 1990s, student numbers at Greenfield College fluctuated, reflecting the economic climate of the day and the State's push to decentralise government schools. Found in amongst the school's archives, an outline of a Principal's speech to the parent body in the 1990s editorialised that 'like the European refugees of the 1950s, Vietnamese families also highly valued education'. Further, it was noted that 'students from these families were more academic in their approach, keen to learn and do well due to corresponding parental expectations'. Just over a decade later, a soon to be retiring principal also made note that it was 'the Vietnamese students who particularly helped set the positive academic tone for refugee and immigrant groups that followed', and the school was 'lucky to have such high performers.'

In 1996, student numbers radically increased, leading to the introduction of a new student management or sub-school system. Here, student year levels were split into three cohorts (junior, middle, senior). The reported reason for doing so was to assist with discipline and student management (Parent Newsletter, 1996). At this point, the school uniform was also reintroduced because 'parents associated a school uniform with discipline' (Principal Newsletter, 1996). From

the early 2000s, concerns over students wearing their uniform correctly and student attendance loomed large, with the current Principal (working as an Assistant Principal and later Principal) warning parents in her newsletter on more than one occasion that 'students not wearing the correct white sock or school tie would be sent home from school'. Significant to this study is that at this same time, the school entered what it called an 'Era of Excellence'; a period from the 2000s to 2010s wherein the single most important priority in consecutive Strategic Reports, Annual Implementation Plans (AIPs), School Annual Reports and most all internal communications unilaterally focused on students achieving 'outstanding' academic results, excellence, and 'performing at the highest standard'.

From 2000-2003, Greenfield College reported its location and demographic information under the heading 'School Profile' in its 'Annual Report to the School Community'. Here a brief blurb about the mid-1950s founding of the school and references to how Greenfield College 'has welcomed new arrivals to Australia since World War II' and, 'how this is reflected in the culturally and linguistically diverse backgrounds of our students, as well as in the multicultural vitality of our community' was also consistently referenced. Similarly included as constants were a few sentences about the suburb's proximal distance from the city and airports, available public transport amenities, and the major roads and highways in the suburb's vicinity.

In these years, the annual school reports also included increasingly specific socio-economic information under the category of 'demographics.' Provided here were named references to other government and non-government secondary education providers in the local area, more specific information about the different language groups represented in the school and the claim that 'the unemployment in catchment areas for Greenfield College ranks among the highest in the state' (Annual Report to the School Community, 2004).

From 2004, the rhetoric of 'Like-Schools Group' (LSG) entered the School's Annual Report to the School Community. This was a State government Education accountability policy mechanism focused on supporting schools in their efforts to monitor and improve their effectiveness enabled by comparing themselves to other 'like' school groups. The two metrics of comparison were the socio-economic status of students, and the number of students speaking a language other than

English. After 2008, however, the specific socio-economic comparison of students living in families receiving the low-income support Educational Maintenance Allowance (EMA) and/or Youth Allowance income support payment for students was removed and replaced by a new comparative index; the SFO (Student Family Occupation) – a metric more broadly based on parent/guardian occupations and whether a language other than English is spoken at home.

Coinciding with the introduction of the SFO was a more concerted effort by Greenfield College to enculturate the school ethos with the values of 'excellence', 'high expectations', 'success', 'individual achievement' and 'high performance'. This is evidenced in the minutes of all internal committee and leadership meetings, the purposeful inscription of these values in progressively revised iterations of the 'school vision and values' running down the margins of the Principal Newsletters, the placement of the values of 'Excellence', 'Leadership', 'Integrity' and 'Respect' in prominent positions on the school's nascent website, and documentation associated with proposing, supporting, and running a plethora of new programs, policies, initiatives and external partnerships, including a growing number of individual specialists who entered the school to support individual 'student academic performance'.

This new disposition particularly resonated in the various submissions and explanations recorded via internal meeting minutes for decisions related to aligning internal teaching and learning programs to deliver a series of State Education curriculum policy reforms. These included the introduction of new mathematics subjects, introducing VCE subjects in Year 10 to lift the school's median ATAR score (the ranking of all Year 12 results compared with all other final year students in most other Australian states), stripping back 'low scoring' VCE subjects offered to students, and allocating more time to prioritise basic Literacy and Numeracy based subjects. Here a plethora of internal documents and various correspondences were consistently found stating that the purpose of these programs was to improve the standardised NAPLAN testing results published in the Annual Report to the School Community, and on the Australian government's *My School* website (https://www.myschool.edu.au/).

Notable amongst internal and external documents was the increasing appearance of corporate-style language such as 'value adding', referring to students as 'clients' and 'customers' in external

consultant reports, data sheets attached to minutes records from senior curriculum committee and leadership strategic planning meetings; particularly those introducing, consolidating then mandating all students from Years 9-12 regularly participate in developing business and community partnerships with employment groups, local businesses, corporations and social enterprises as part of their 'extended' and 'extra-curricular' learning programs.

5.2 Making sense of Greenfield College's local neighbourhood

Of course, the way Greenfield College presented itself on paper and on its website did not entirely match how the school was encountered as a physical place. For this reason, the following section now provides a reflection on how one encounters the physical place of Greenfield College in person when one arrives in the school's environs.

Scuffed and stained orange brick pavers laid in front of the school's main gate make clear to visitors and parents where the neighbourhood boundary meets the school. In between the pavers and the school lies a well-trodden uneven footpath that runs parallel to the busy suburban road outside the school. Every day this main thoroughfare carries more traffic than it can handle; particularly at school drop-off and pick-up times where a traffic supervisor wearing a fluorescent yellow vest pushes the button of a dedicated set of pedestrian traffic lights that the local Council recently installed to help incoming and exiting students from Greenfield College safely cross the road. Here it is not uncommon to observe double, and sometimes triple, parked SUVs, people-movers and four-wheel drives doing battle with smaller hatchback runabouts or less expensive station-wagons as either or both block traffic at the designated pick-up and drop-off hotspots.

Within five minutes walking distance to the west of Greenfield College's front gate is the suburb's main shopping strip. Here an assortment of cafés, pharmacies, real-estate agencies, Asian grocers, $2 shops, 'cheap-eats' take-away food bars and empty shops line the main street: some with plastic tables and chairs crowding the already too narrow footpath. Other small business traders try to tempt passing foot traffic with baskets of inexpensive imported goods or bulk packages of toilet paper, tissues, toothpaste, and soap or freshly squeezed sugar cane juice that is pumped out into plastic cups and bottles using an industrial size juicer blocking foot traffic on the footpath outside the retailer's shop. Bilingual advertising signs on shop front windows and/or the edge of the footpath are commonplace.

Before and after school, many students from Greenfield College hang around or walk through their local shopping strip. Year 12 students are also permitted to visit the local town centre at lunchtime. After school, a few students will make their way across yet another main road to get to train station, whilst others will head to McDonalds or wait outside one of the bargain $2 shops for one of several local buses. Some students appear to be in no hurry to go anywhere. Instead, they slowly make the journey home by foot either alone or with a small group of friends, chatting as they walk.

Around the back and side perimeters of the school sit an assortment of 1950s apricot, beige and dark orange double or triple fronted brick veneer houses, interspersed with tired weatherboard homes, most with peeling paint and faded tin roofs. Eucalyptus, old pine trees and other spindly natives provide a smattering of greenery in these streets but it's not enough to soften the hard surfaces of concrete, gravel, bitumen, and brick that otherwise dominates. Most front lawn areas of residential homes have turned to dead grass and dust as a consequence of being used for extra off-street parking. Occasionally interrupting the streetscape is a vacant fenced off lot being readied for a rebuild. Whilst 'For Sale' and 'For Lease' advertising boards on homes surrounding the school are rare, when they do appear found down the bottom in large print is the phrase, 'in the Greenfield College zone'. Other rental homes directly abutting the school – irrespective of condition - are rarely vacated by families of students attending the school.

5.3 Buildings and grounds

The mid-2000s saw the physical appearance of the Greenfield College change significantly. During this period, new buildings were completed, whilst old buildings were redeveloped or renovated. New 'fit-for-purpose' buildings were opened - including a state of the art open-learning science centre, performing arts theatre, a trade training centre, revamped library, careers centre and senior study centre. All surfaces between buildings were sealed with dark grey asphalt. All classrooms and staff areas were repainted and recarpeted using the same dark grey and navy colour palette which matched new rectangular shaped two-seat tables and dark blue-grey plastic chairs that were used in all classrooms across the school. Toward the back and side perimeters of the school, active spaces were also overhauled. These included laying a new soccer pitch, new tennis courts and developing new athletics facilities, all locked behind high wire fences.

In 2007 the entrance to Greenfield College was completely overhauled – including the entrance, front yard, and gardens; an effort to improve both the functionality and aesthetic appeal of the school's passive spaces. In Principal newsletters and internal correspondences, the Principal explained to her local community that all aspects were designed to present the school as a school of 'excellence' and 'high performance'. Correspondingly, from 2007 Greenfield College stopped showcasing its socio-economic and cultural profile on its website as its point of difference. Instead, this specific 'place' information about the school's demography was marginalised under a tab called 'extra information', replaced by photographs of smiling students – mostly girls - and paragraphs of text that reported in glowing terms how Greenfield College was 'defying its postcode' by being a 'high performance' school that was exceeding its academic excellence success targets, particularly amongst girls (Website archives, 2006- 2018). In contrast to the residential homes immediately abutting the school's boundary fences, life inside the school gate of Greenfield College appeared to be an oasis. This is a place that speaks of order, safety, security, and success. This façade is no accident. Since the mid-2000s, 'the school has committed to a sustained program of facilities upgrading to improve the learning and work environment for students and staff, and this is evident from the front gate to the sports oval' (Website archive, 2018).

In 2007, a heavy black steel front gate and a tall, industrial steel fence of spiked pickets completely fenced off Greenfield College from its surrounding neighbourhood for the first time in the school's history. Immediately located just inside, a carefully pruned avenue of deciduous ornamental pear trees welcomes visitors and students to the school, providing much needed shade in the hot summer months. This main entrance path runs directly to the Main Office then all the way back to the 'new state-of-the-art Science' centre. Over the past several years, these trees have also been frequently used as a background for marketing photographs in school Prospectus documents.

Meticulous attention is paid to professionally maintaining the school grounds. Twice per day the full-time maintenance crew in their high-vis fluorescent yellow and orange shirts use their ride-on industrial vacuum to keep spotless the dark green artificial turf that spreads across the full breadth

of the school's substantial street frontage. Artificial turf is also found in other parts of the school where its deep green aesthetic is used to break up the dark grey asphalt that surrounds a passive recreational area, its shade cloth protecting middle school students from the hot summer sun.

Looking through the school's Yearbooks and *Google Earth* images over the past several decades reveals that all that remains of the non-bounded original shrubbery, trees, and native grasses of the front area of Greenfield College in the 1950s are the few large eucalyptus trees that now stand like giant sentries guarding the school's triple-storey landmark building built in the 1970s. Cutting through the expanse of artificial turf at the school's front is the path used by students at the end of the school day if they are heading off by foot in the direction of the main shopping strip or train station. This slightly meandering, smooth edged concrete path leads students from their classrooms and steel shuttered external locker bays to the heavy steel sliding gate that is programmed to open only at the end of the school day.

Elsewhere in the school, clean, ordered straight lines are common. This includes the array of external locker bays installed several years ago to free up space in the corridors as enrolments and therefore class sizes at Greenfield College grew. These purpose-built spaces are colour coordinated to match the industrial palette used in the rest of the school, deep blue-grey walls and cream roller doors. In a Parent Newsletter (May 2015), parents were advised that 'to maximise the security of student's possessions in the external locker bays, CCTV cameras have been installed and the locker bay roller doors can be padlocked overnight'.

Continuing the external focus on clean lines and symmetry is the concentrated use of short, varnished wooden poles married with low hanging, draping steel chains found all around the school. In all cases, the clean unassuming lines of this unobtrusive fencing marshals students away from 'out of bounds' areas, including the three metre 'no man's land' space around the back perimeter of the sports oval.

Principal Newsletters published from 2006-2008 regularly updated parents on the redevelopment of school buildings and the grounds. In addition, images of redeveloped passive areas are also prominently displayed throughout school prospectus documents. Here, purposefully constructed images present an equal number of boys and girls enjoying their outdoor environment in a manner

that infers respectful cooperation with each other and the surroundings. The notion that there is a reciprocal relationship of care and protection is also suggested by the way students use various seating options, the upkeep of plantings and the provision of both natural and synthetic shade options for students. Noteworthy here too is the complete absence of litter and supervising staff; again, a subtle reference to pervasive influence of the values of respect and leadership that underpin the school's ethos.

5.4 The internal spaces of Greenfield College

In February 2004, major works were undertaken to relocate the administration area of Greenfield College to the front of the school. This enabled the conversion of the previous space into classrooms to meet the needs of the growing school population. In 2007, the administration area was given a major facelift, emerging with light paint, an infusion of quality wood finishes on sliding glass doors that close off a substantive conference room. Also altered was the lighting to allow my natural light in through new sky lights, creating a more open atmosphere. In 2018, the reception area for parents and visitors presents the school as professional, modern, and forward thinking. For a first-time visitor, the reception area clearly suggests this is a school that not only speaks about success but also delivers.

Immediately upon walking through the glass door entrance, parents and visitors are confronted by a wall lined with the school's 'High Achievers'. Framed portrait photographs of Year 12 students from the previous two years who achieved outstanding examination scores and secured university places in medicine, law, commerce, or dentistry from the 'Group of Eight' Australian Universities dominate. Standing watch and connecting current and prospective students, parents, and visitors to the pride the school promotes about its history and past students' achievements, is a mannequin immaculately dressed in the current school uniform which stands just far enough away not to obscure a visitor's view of the glass cabinet that holds the school's original 1956 brass bell.

Four small chairs found hugging the perimeter of the waiting area resemble those that might be found in a corporate office. Here promotional materials in the form of leaflets, prospectus documents and a copy of the current yearbook can also be found. The office staff themselves are

dressed in office attire and sit behind glass sliding windows in front of computers. Clean lines and professionalism once again dominate the observed school space.

The view of the working area behind the glass is also corporate in nature. With up to eight workstations in a semi-closed cubicle arrangement, the impression created from the outside looking in is an efficient commercial business. The hierarchy of administration personnel is made clear by way of the Bursar and Principal's office, situated towards the back of the space next to windows, are also afforded the option of privacy as their separate self-contained office spaces have a door that can be locked that otherwise connects them to the main office area. Both the Principal and the Bursar have complete accessibility to the office area and office staff. Sponsorship signs and awards with sponsor logos from various corporate, local business, local government agencies and social enterprises are also on display in this front area, albeit in a manner that appears secondary to the student profiles affixed to the walls in the waiting area.

Visitors sitting in the waiting area have no option but to face an adjacent wall where a similar display of framed student photographs holds pride of place. This time the sign above reads, 'Student Leadership'. Unlike the opposite wall where the focus is on individual excellence, on the 'Student Leadership' wall up to eleven students are pictured in each frame. This infers the school values not just the individual staff of school Leadership teams (who are named) but also the teamwork and leadership skills that each uses to build their individual success.

Located in an adjacent building, the décor of the walls, doors, furniture, carpet, and blinds in staff working areas returns (and continues) the broader classroom theme of a dark industrial blue-grey colour palette. Here the general teaching staff work in rows of pine laminated desks – four desks across – in a maze-like formation. Many desks need updating, as do some of the swivel chairs which lean precariously to one side. Staff are not permitted to attach posters or personalise nearby walls with photographs. Some of the bookcase hutches attached to the desks are overflowing with books, papers, and folders whilst others have minimal visible materials. Staff here sit close together, and mostly in silence. Many of the seventy or so teachers who work in this space wander about with headphones, creating a further sense of disconnection. This is solidified by the Teacher-Leaders who sit in a smaller glass fronted room that provides a clean line of sight

between Teacher-Leaders and the general classroom teachers. These school leaders have larger, newer desks and larger, more comfortable desk chairs. The colour scheme in their room is no different but everything else about this leadership space infers the team enjoy perks and power associated with occupying a higher position in the school's organisational hierarchy.

For the most part, the staff social area located nearby is almost always found empty. Here large tables are pushed together and sets of 6-8 fabric chairs are positioned around each table in an island formation. Used by only a handful of staff for lunch and morning tea, or when the Principal decides to do an impromptu Staff Briefing or farewell, or by some staff to do their marking free from distraction. Otherwise, most staff choose to eat at their desks whilst working.

5.5 The in-between places of Greenfield College

Most corridors in the student learning areas of Greenfield College feature highly polished blue or grey vinyl floors and dark industrial-military blue-grey skirting that perfectly matched the doors. Little if any litter is visible. Noteworthy in the two stairwells in the 3-storey senior school building is a broad yellow hazard line painted up the stairwell's centre. Its bright fluorescent paint reminds me of the paint used in the car park to mark out the 'no parking' zones.

In 2015, an extensive re-painting program across the whole school resulted in all internal walls of the school being re-coated with an off-white paint and the external doors of most all classrooms being totally repainted in a high-gloss deep shade of military grey-blue. This heavy accent colour is found replicated throughout the entire school, including every classroom, every staff area, and all areas of the administration building, save the front office. In the corridor spaces running through the centre of classrooms, it is rare to see student work on display, despite the presence of large (empty) pin boards that would make this possible. In the old Science building where only the Year 9 and Year 10 Maker technology classes take place, an enclosed large wooden cabinet that could easily hold teaching and learning artefacts of different sizes is also found empty.

Thomson and Hill (2017) argue that examining school displays means investigating what is being said and done in relation to the displays, and what is not' (p.108). In the case of Greenfield College, there appears to be a striking difference between how the accessible wall space in the administration building is used compared to the non-use of the display space in classrooms and the 'in between'

spaces of corridors and stairwells. Whilst leadership is clearly making considerable use of displays in the Administration building to the extent that the walls themselves are almost a living prospectus bearing testament to the school's ethos, there were no such tangible demonstrations that student learning was valued in other non- public spaces of the school. Rather, an overwhelming sense of absence – and silence - of displays of student work and pedagogic materials is felt. Here, Thomson and Hill (2017) suggest researchers consider this may reflect inconsistent and shared room scheduling, staff workload, competitive students not wanting to share their work in addition to an individual teacher's apparent 'lack of commitment' when seeking explanations for this non-use of display space.

In contrast, consistently announcing its presence in every classroom of every building in the school, positioned at the front of the room in precisely the same way, are laminated, A3 branded signs of the school logo proclaiming the school's ethos, student 'rights and responsibilities' and the whole school standardised pedagogical instructional model that all teachers – and students - are expected to follow. Likewise, the laminated sign 'It's not okay to be away. 90% Attendance. No Less' is also found at the front of every classroom, around all locker bays and taped to all glass windows facing outwards into the corridors, again in every building of the school, including the toilet block. There is 'a strongly normative element to [these] displays: they were a visual reminder of what teachers and students must do every day' (Thomson, 2017, p.111). In this sense, the uniform placement of these school branded signs across all buildings, and all classrooms, in the same way, also appears to signify a regimented 'associational purpose' insofar each works to 'create stories of affiliation [and] create an emotional attachment to the school' (Thomson et al, 2007, p.397).

5.6 The relational entanglements of Greenfield College

Whilst examining Thomson and Hall's (2017) 'blades of grass' (p.13) view of Greenfield College does much to assist this study's efforts to place the reader in the time and place context of the school, thus far still missing is a sense of how the 'neat and tight boundaries' thus far described have entangled over time with the views and values of 'stretched out social relations [that] are inevitably and everywhere imbued with power and meaning and symbolism [in] an ever-shifting social geometry of power and signification' (Massey, 1994, p.3). Thus, the next section of this chapter now provides a summary of the school's 'relational entanglements' found flowing in,

around, through and beyond the school gate of Greenfield College; sometimes never to return, other times reappearing on a regular basis. Doing so is important to this present study as each relational entanglement contributes to our developing understanding of how the external political context – and particularly Connell's 'gender order' - informed, shaped and influenced the internal world of Greenfield College.

Greenfield College's Engagement with State Education Policies

Particularly significant to this study is the relational entanglement of education policy. Several education policy documents were discovered in the school's archives whilst others were provided to me by one of my Teacher-Leader interview staff who passed over both his well-thumbed paper copies of policy documents that had informed his work as a Teacher Leader in Improvement, Curriculum and Assessment since the 1990s, and copies of his digital files. Each was closely scrutinised tagged and scribbled upon, looking for understandings of 'gender'; particularly after being advised by several interview staff – including the Principal herself – that the school leadership team prided itself on the way it thoroughly adhered to state government Equal Opportunity and other education policy requirements, following each 'to the letter', whenever the school was required to (re)develop policies, practices and processes, including its design of curriculum, assessment and pedagogy.

Accordingly, my examination of 'found' policy documents, reports and position papers - *Enhancing their futures: Report of the Committee of Review of the Victorian Certificate of Education* (1997), *Blueprint for Government Schools: Future Directions for Education in Victorian Government Schools* (2003), *Student Voice Report* (2007); *The Melbourne Declaration on Education Goals for Young Australians* (2008); and the ACER report, *Why not the Best Schools Report* (2008) – discerned that the term 'gender' either did not appear or most often appeared as a category of analysis, an adjective to describe 'gender difference in performance', an explanatory variable to describe educational outcomes, included with single sex schools and disability, a factor to differentiate proficiency levels in reading and numeracy or a weighting factor used to determine the validity of results. Furthermore, no mention of the term 'gender' was found in the *National Review of Teacher Registration Consultation Paper* (2018)*,* the *One Teaching Profession: Teacher Registration in Australia* (2018), the *Evaluation of Australian Professional Standards for Teachers* (2016) or the *Through Growth to Achievement: Report of the Review to Achieve Educational Excellence in Australian Schools* (2018).

Regarding STEM policy documents used in the school, I soon discovered that the term gender was either absent or found as a demographic data descriptor for sex or as an adjective in statements such as 'gender disparity in STEM employment' in the *National Science, Technology, Engineering and Mathematics (STEM) School Education Strategy* (2015) – both endorsed by all Australian Education Ministers to deliver improvements to STEM education - the *Summary Report from the STEM Summit* (2015) and the *Optimising STEM Industry-School Partnerships: Inspiring Australia's Next Generation Report* (2018). Perhaps unsurprisingly, the term gender was also not found in the mandated Victorian Curriculum (F-10) Digital Technologies curriculum policy published by the Victorian Curriculum and Assessment Authority (VCAA) in 2017 which mandated all Catholic and Government schools plan for implementation from 2017, then deliver from 2018.

External partnerships entering the school

Similarly found knotting, entangling, and informing the ethos of Greenfield College were a range of external school improvement interconnections. Here whilst the term gender was found either absent or simply as a demographic category, values associated with the school's 2018 ethos of 'high performance', 'excellence', 'high ability' and 'success' abounded in a raft of external 'stretched out relations' which consisted of long-standing relationships with a range of corporate sector businesses keen to participate in the 'business of learning', corporate not-for-profit social enterprises focused on leveraging teacher efforts to help students 'lift their potential beyond their postcode, high profile tertiary education research partners, professional leadership training bodies, key advisers from the Department, local businesses and various individuals – including university sector pedagogues, former Principals, retired teachers - employed as external consultants to build the 'professional capital' of staff in data analysis, assessment, content knowledge or pedagogics skills.

External organisations run by a range of for-profit businesses and not-for-profit organisations offered extra-curricular programs to students over the course of the year. Occasionally these focused on health, but more often students listened to entrepreneurial career support and personal growth career programs, again focused on their individual success.

Since 2013 the school had also invested considerable funds in building the leadership capacity of aspirant Teacher-Leaders and Assistant Principals by facilitating their attendance at specialist programs run by the Bastow Institute (bastow.vic.edu.au). Established in 2009 as the 'professional learning arm of the Victorian Department of Education and Training', Bastow's mission is to assist

school leader efforts to ‘set and meet high expectations’ to ensure ‘excellence’ through delivering programs in partnerships with external organisations from the higher education, commercial and not-for-profit sectors.

Additionally, Greenfield College’s internal document archives revealed the school had progressively brought in an increasing array of education consultants to support and coach staff in using the school’s specially branded, standardised instructional pedagogical model to deliver its ‘guaranteed and viable curriculum’ across the school. From 2012, the Principal used monies secured through a variety of ‘Improvement’ grants from DET to ensure all new teaching staff members were inducted into using the school’s standardised pedagogy model from the very first day of their employment. Here, the same external consultant was repeatedly used to coach existing staff in ‘refresher’ courses each year. Expectations of staff compliance in the use of this school-branded pedagogical instructional model was closely monitored, featuring as a focus area that all teachers were required to furnish evidence of using in their ‘Performance Development Plan’ professional review that took place annually with a senior member of the school’s leadership team.

Moreover, an increasingly prevalent ‘relational entanglement’ found in the school archives was the increasing use of external consultants offering external testing services for students from Year 7 to Year 12. These external consultants – many of whom were retired principals, teachers or privately run businesses – came into the school to set up and run tests which they then assessed, generating, and supplying the school leadership with data reports which were then scrutinised by the Principal to determine areas to target for future ‘academic growth’ and ‘whole school improvement’. In 2016, the focus of data gathering also turned to students reporting back on their teachers’ performances – including students reporting on the extent to which each classroom teacher was adhering to the standardised instructional pedagogy model - four times per year (once per term). Marketing itself as a ‘social impact business’, the supplier of these ‘invaluable insights’ was a for-profit external provider who proclaimed amongst its company beliefs ‘actionable, evidence-based insights’ and a belief in ‘equal opportunity’ insofar as ‘every student should have the best possible learning opportunities regardless of their circumstances’ to maximise ‘their personal academic performance’.

Further, since the mid-2000s, an increasing number of external support mechanisms and agencies also entered the school to assist students, almost always to supply an academic improvement service. These included alumni study buddies, external tutors teaching students after school classes on a

weekly basis, guest lecturers and subject specialists offering advanced academic lectures, and 'optional' afterschool practice exam sessions run, monitored, and assessed by external providers.

Finally, in the lead up to the final exam period in October of any given academic year, all final year Year 11 and Year 12 students were required to attend and participate in a range of 'exam study boot camps' run by another group of private agencies, sometimes consisting of high-achieving, successful, just-graduated peers. Such sessions – prioritised over 'normal' lessons inside the school day - included showing students how to 'be note-taking genius' and how to 'painlessly cram and smash your exams'.

5.7 Summing up and looking forward

This chapter has introduced and explored Greenfield College as a place, as it is presented on paper and personally experienced both inside and beyond its school gate. By walking around the school's grounds, physical buildings, and internal spaces, then also exploring the local neighbourhood in which Greenfield College is situated and the school's digital and hardcopy document archives, this chapter has discerned that far from being a neutral backdrop to the action of girls' engaging with Maker technologies, the 'look and feel' (Hodas, 1993) of the school has helped shaped (Cuban, 1986; Tyack & Tobin, 1994; Hodas, 1993) an image of Greenfield College as an exacting, 'high performance' academic school, that has materially sought to separate itself from its local neighbourhood, thus presenting Greenfield College as 'a stable, self-sufficient mini-polity, able and willing to look after whatever sits within its neat and tight boundaries' (Thomson and Hall, 2017, p.74).

This chapter's discernment of Greenfield College's 'political arena' (Tyack & Tobin, 1994) has heeded the advice of Monahan (2005) by undertaking an investigation of the materiality of 'space, pedagogy, organization, policy, governance and imagination'. This, in turn, has surfaced the implicated power relations that are historically 'infused with values and ideologies of their creation' (Monahan, 2005).

Moreover, the initial 'macro' place-based exploration of Greenfield College outlined in this chapter has also rendered visible the porosity of the seemingly solid boundaries Greenfield College and the increasing number of entangled relations that have entered the school gate over the past several decades, including a suite of mandated State government Education policy operational directives and curriculum initiatives, and an ever-increasing number of external partnerships initiated and forged by

the current Principal of Greenfield College to deliver the 'high performance' agenda set down by State government Education policies.

Undertaking this exploration is essential to locate how neoliberal values associated with the school's relational entanglements, material, and spatial aspects of place work in concert to 'imping[e] on the staff of schooling as a quite tangible force' in a manner that is always 'palpable and present' (Seddon, 1995). Noteworthy here too is how the 'built pedagogy' (Monahan, 2005) of Greenfield College is made manifest by the school's retreat from its responsibility to deliver social programs at the same time Greenfield College began to undertake its physical rebuilding and organisational restructuring, branding, and marketing itself as a 'high performance's school of choice.

Moving forward, whilst Chapter 5 has begun the process of surfacing the 'situational specificity' of Greenfield College by noting the 'particularity' of the school as emplaced within its local neighbourhood, the next three Findings chapters will now further investigate and build the multi-layered meso and micro place narratives living inside the school. Here the making sense focus of each is on locating not only how Maker technologies are used in the school, particularly by girls, but more so how the neoliberal values of broader society have shaped and influenced the school's institutional and pedagogic conditions operating within Greenfield College, and particularly staff members' understandings of gender which shape and influence girls' engagement with Maker technologies in the school.

Chapter 6. FINDINGS II – Staff Perspectives of the place of Maker technologies in the school

In this chapter I report my findings from various staff interviews and conversations that took place in the fieldwork. Here nineteen staff members working in various positions in Greenfield College contribute their voices to this study's developing conversation about the place of Maker technologies in the school (see Figure 6.1). These perspectives are broadly grouped around the first three of this study's research questions:

1. How did Maker technologies – and the idea of Making – find a place in the school?
2. How did the institutional and pedagogic conditions of the school influence the use of Maker technologies?
3. How did understandings of gender shape girls' engagement with Maker technologies in the school?

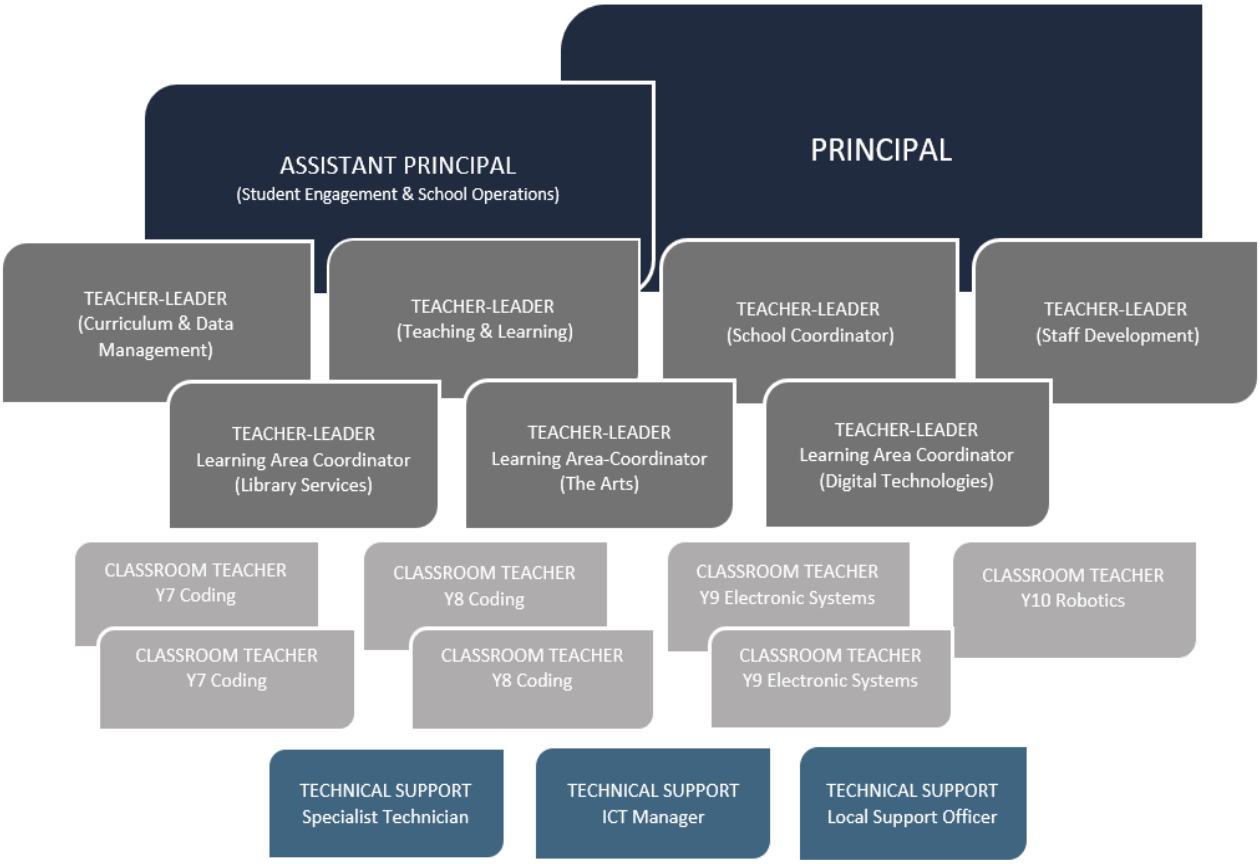

Figure 6. 1 Greenfield College staff interviewed for this study

Each staff member has been allocated a reference code, which is threaded through this chapter and the Chapter 7 and Chapter 8 (see Table 6.1)

Interview Participant Codes

Position		Sex (M/F)	Years at the school	Reference
Principal		F	35+	(F, 35+)
Assistant Principal	Student Engagement & School Operations	M	25+	(M,25+)
Teacher Leader	Curriculum & Data Management	M	40+	(M,40+)
	Teaching & Learning	M	10+	(M,10+)
	School Coordinator	M	30+	(M,30+)
	Staff Development	F	35+	(F,35+)
	Learning Area Leader Library Services	F	5+	(F,5+)
	Learning Area Leader The Arts	M	10+	(M,10+)
	Learning Area Leader Digital Technologies	M	30+	(M,30+)
Classroom teachers	Year 7 Coding	F	40+	(F,40+)
	Year 7 Coding	M	10+	(M,10+)
	Year 8 Coding	M	30+	(M,30+)
	Year 8 Coding	M	20+	(M,20+)
	Year 9 Electronics	M	15+	(M,15+)
	Year 9 Electronics	M	25+	(M,25+)
	Year 10 Robotics	M	30+	(M,30+)
Technical Support Team	ICT Manager	M	10+	(M, 10+)
	Technical Support Technician	M	25+	(M, 25+)
	Technical Support Technician	M	15+	(M, 15+)

Table 6. 1 Interviewed staff member reference codes per sex and years at Greenfield College

6.1 The place of Maker technologies and the idea of Making in the school

In many ways, the first research question could be read along instrumental lines, focusing simply on determining the extent to which staff are aware of the type of Maker technologies used in the school, how, and by whom. Here staff were provided an opportunity to reflect upon how Maker technologies came to enter and be used by students in the school.

Regarding the various Maker technologies used in classrooms from Year 7 – 10, there was little awareness about what specific Maker technology was in situ, with many staff offering a guess or describing what the Maker technology did or looked like, often finishing with a sometimes exacerbated, 'you know what I mean!'. Only the Teacher-Leader of Digital Technologies (M, 30+) and the Technical Support team (M,10+; M,25+; M,15+) accurately named all types: *Scratch*, *Ed-Create*, *Arduino Sphero, Raspberry Pi* in the Junior School, and 'the good old' *Dick Smith* Electronic Circuitry Kits and *Lego Mindstorms NXT* Robotics in Years 9-10. Interestingly, neither the Principal (F,35+) nor the Assistant Principal (M,25+) was able to specifically name the type of Maker technologies used in any of these classes although like all staff, both knew no Digital Fabrication Maker technologies were

present in the school. In this regard one of the Technical Support technicians (M, 15+) mused how 'not so long ago' he had tried to bring in a 3D Printer:

> 'just to show the students. I went and borrowed one from another school on the other side of town, put it in the car and brought it over here. I used it with a teacher who was into the Maker stuff who has left the school now. The kids really liked it. I know a request was put into buy a 3D Printer, but it was knocked back by finance as inappropriate as there was no formal curriculum or assessment written up to support it'.

There was also no consensus regarding how Maker technologies came to enter the school. Here despite their former admission about not knowing the types of Maker technologies, both the Principal (F,35+) and Assistant Principal (M,25+) were adamant that it was purposeful strategic planning that introduced Maker technologies to the school. Contrastingly, staff located closer to the everyday classroom - Teacher-Leaders and classroom teachers (see Table 6.1) - were quick to offer the contrary view that maker technologies at the Junior level had been introduced to Greenfield College in a 'haphazard', 'piecemeal' and 'ad hoc' manner, mostly 'driven by individual teacher interest' or a 'teacher passion to engage students' and at the Middle School level, to reflect the school's longstanding offering of Year 9 Electronics and Year 10 Robotics as elective subjects.

Regardless, a sense of great optimism was evidenced across all staff perceptions about what students stood to gain by engaging with Maker technologies and Maker Education. Here almost all pointed to the idea that Maker technologies offered students unfamiliar with digital technologies a 'fun and engaging' way to develop 'essential 21st Century skills', with the technical support technicians becoming more animated when arguing it was 'vital' for students to engage with Maker technologies because these 21st Century learning skills 'would be the 'bread and butter' of students' future lives (M,15+; M,25+). Furthermore, it was only these technical support technicians who pointed to the more pragmatic benefits of Maker technologies, in the form of learning technical skills. Here, one team member explained that students engaging with Maker technologies was a very important to students' future working lives because 'experimenting and debugging' are skills that 'everyone needs in today's day and age' (M, 25+). Here most all classroom teachers emphasised the problem-solving affordances of Maker technologies, with one Teacher-Leader (M,10+) also distinguishing student learning with Maker technologies as a collective rather than collaborative endeavour:

> 'In every classroom you can see the kids in the class working together – yeah sure – that's collaboration. But in the stuff I give them to do, they have to work as a collective to achieve a single goal, you know, one machine with a single engine. That's the difference. That's where they learn to put their individual wants on the back burner and instead think about what the whole group needs'.

Noteworthy here too was that it was only the Junior School (Year 7-8) classroom teachers who suggested that providing students with a 'safe space' to 'play' with Maker technologies was an important way to teach students to 'experiment and take risks' (F, 40+; M,10+; M,30+; M,20+), and that this was something they would otherwise have 'no chance to do' in any other subject in the school.

Finally, both the Principal and her long-serving Teacher-Leader of Staff Development suggested that girls' longstanding lack of interest in Maker technologies in the Middle Years (Years 9-10) was a consequence of the 'gendered nature' (F, 35+; F, 35+) of the technologies used. Also used as a reason was girls' lack of confidence and unwillingness to subvert the negative stereotypes associated with taking up the 'hard sciences' (M,25+; M,30+) and technology-based subjects more generally. Here one Teacher-Leader (M,10+) went so far as to say that without the 'critical mass of a large group of girls to offer each other mutual support to combat [these] stereotypes, this situation had no hope of ever changing.' Additionally, only the Junior (Year 7 - 8) classroom teachers attributed the school's 'high stakes, academic results push culture' and/or the Principal for not doing enough to 'break down these negative stereotypes' because she was 'too interested in pushing them to get results' as a key factor to consider when seeking to explain girls' lack of interest (F,40+; M,10+; M,30+; M,20+).

6.2 The institutional and pedagogic conditions of Greenfield College

The second research question framing these conversations concerned how institutional and pedagogic conditions influences student engagement with Maker technologies. Here staff offered their thoughts about scheduling, funding, learning spaces, support for teachers and pedagogical practices. In sum, little common ground was found in staff views of how institutional 'situational constraints' (Cuban,1986) related to these areas impacted student engagement with Maker technologies in the school.

Scheduling Maker technology classes

Regarding scheduling, all Junior School classroom teachers attributed the brevity of lessons (50 minutes), the number of allocated lessons in student timetables per week (two) and the short duration of elective subjects (one Term in a two-year cycle), as major 'stumbling block' to students taking up Maker technologies subjects in Year 9 and Year 10, then computer science in the Senior years (F,40+; M,10+; M,30+; M,20+). Here, one Teacher-Leader (M,40+) also disclosed that over the past decade, the school's prioritisation of its SEAL program (Select Entry Accelerated Learning) to

attract the 'brightest' Year 7 students from the local neighbourhood and beyond, severely limited the timetable space for running elective subjects, such as Maker technologies. Further, although the Principal acknowledged that her entire SEAL cohort and some Year 7 and/or Year 8 students may miss out on experiencing Maker technology subjects due to limited blocking and 'rotating nature of the timetable'(F,35+) the matter was foreclosed in favour of supporting the school's SEAL students to accelerate as per the marketing information provided to parents when their children first sought entry in a highly prized Year 7 placement:

> 'in theory the timetabling of the elective program works quite well, but I do realise that in practice sometimes a child can miss out on certain things just because of the rotation of things - they might change class between 7 and 8 so there's some risk in there in terms of access. Not much we can do about that, especially for SEAL students whose parents sign up to accelerated program that we have no choice but to deliver'.

When pondering this same quandary, another Teacher-Leader (M,30+) instead questioned the strictures imposed on students by the school's longstanding timetable, ruminating if it was still 'fit for purpose' and 'in today's world' if it worked in the best interests of students, including those enrolled in SEAL classes. Likewise, almost all classroom teachers spoke at length about SEAL students being 'unfairly' denied access to Year 9 and Year 10 Maker technology electives because they had no choice but to 'give up' their elective options to complete advanced Mathematics at a year level ahead of their cohort. Here the Teacher-Leader of Digital Learning Technologies (M,30+) appeared particularly frustrated by the way the 'best and brightest students - many of them female – were denied the option of picking up Maker technologies at Year 9 or Year 10' whilst another wondered whether the school should modify its elective program 'or make Maker technology subjects core subjects' (M,40+) to make sure SEAL students could experience the benefits of taking on Maker technology, as doing so may help mitigate

> 'the risk aversion of SEAL kids who won't touch subjects they can't memorise and score perfect marks. Too many of the SEAL kids are focused totally on their grades because the students here are totally focused on maximising their ATAR. For the SEAL kids and their parents, this starts in Year 7 - students don't think or care about skills - just grades'.

Relatedly, thoughts offered by staff concerning shifting the Maker education subjects from elective status to core subjects suggests broad awareness about the primacy of the timetable in dictating student options to learn with Maker technologies, but no appetite for change for a variety of reasons,

including the 'problem' of change-adverse teaching staff or the agenda of school leaders dictating subject programming in the school (see Table 6.2).

Assistant Principal (M,25+)	'There's no room in the timetable for the Maker electives as a core subject. This would require a major shift, a major revamp in 'how we do things here' which would require getting everyone on board– as a leadership team we have certainly spoken about this but at the end of the day, we have the constraints of space, constraints of the timetable, staff who are risk adverse and expectations of parents to deal with'.
Teacher Leader (M,30+)	'There is no consideration of shifting - the problem is other core subjects would need to drop - the only way we could do this would be to change to a 10-day timetable and create extra periods. We would need to educate staff and convince them of the benefits of the Maker mindset and pedagogy, so they don't mind 'losing' some of their contact time'.
Teacher Y8 Coding (M,20+)	'It looks like it's a core subject now but it's not – it's still an elective – which sort of tells you how much the school values it'.
Technical Support (M,10+)	'I don't think schools think about the IT– or the digital Maker stuff - as a sequential teaching program – so yes, they do a semester of *SCRATCH* – but then what? No one has thought this through – no one has thought how to link the programming to the robotics or the electronics – the focus has always been on the other academic teaching programs – with the IT stuff on the margins, off to the side. There's a whole heap of structural barriers here that need to be thought through. And until they do, the needs of the kids will remain on the periphery'.

Table 6. 2 Stakeholder views on scheduling issues

A final comment made by another Teacher Leader (M,40+) here is also telling: 'it is the SEAL kids in Year 7 and Year 8 - who show the most aptitude for Maker technologies - but once they hit Year 9, the timetable strangles them and their future choices'.

Funding Maker technologies in Greenfield College

As stated in Chapter 1, the small but growing body of literature relating to barriers experienced by school seeking to implement Maker technologies in school settings often point to a lack of funding as the central challenge for schools to overcome. Whilst some Technical Support staff and some classroom teachers in Greenfield College concurred with this view, the leaders of the school held a very different opinion. Here the Principal (F,35+) made it very clear that 'funding was no issue' and that she was 'more than happy to pay' for new Maker technologies – including a 'lab full of 3D Printers' but only if staff wanting to bring these into the school 'first furnished her with guaranteed and viable curriculum scope-and-sequence unit plans and assessment protocols to justify how teachers would be using them in the way expected of all other subjects'. This view that 'money was not a problem' was affirmed by one Teacher Leader (M,10+) and one classroom teacher (M,30+) (see Table 6.3).

Principal (F,35+)	'My attitude is you've got to resource the stuff, the school can support it. So, don't let the issue of money get in the way. Don't wait. It's only money – I'm happy to find it when we need it, don't let those trivial things like money get in the way. I also encourage people to apply for extra funds like grants and things and some people do that on their own with my support … we had someone who was a grant writer. And we paid her. And she well and truly paid her fee'.
Teacher Leader (M,10+)	'The Principal has discretionary money that she can access. She also handed out about five grand for the Makers club and now I just go and buy a few things to make what I want to happen. The last time I took the brochures from my supplier to [Teacher Leader] and said, "look, they've got a whole bunch of these little robots - so kids can make these?" And he said, "oh yeah." So, the next thing was we went and bought a whole class set of these self-assembled little robots that the kids could then program; all without going through the global budget process. It's who you know in this place, that's how I get things done!'
Teacher Y8 Coding (M,30+)	'I was told to just go and find things to do – and then go and see the Principal for a chat; then, as soon as I had everything documented, the next thing I knew he would order. This is how we ended up with a class set of *Makey Makey*, *Arduino, Sphero.* Sometimes the boss [Teacher-Leader] would come and ask me what should we get? So, it was through him that we purchased a whole bunch of things – no questions asked'.

Table 6. 3 Views on how the purchase of Maker technologies is funded

Indeed, the Principal's conditional support for approving the purchase of Maker technologies appeared well known. From the Assistant Principal to Technical Support staff, all were aware of the Principal's directive to tie new Maker technology purchases explicitly to her standardised curriculum, assessment, and pedagogical policy expectations (see Table 6.4).

Assistant Principal (M,25+)	'There has been a push to get a 3D printer, but we will not even entertain this purchase unless the teachers can tell us how they plan to use them in the curriculum. We're not going to buy something just because it's the newest fad. Same applies to laser cutters. Until the curriculum is written and designed to show there's a need and a purpose, it's not going to happen'.
Teacher-Leader (M,40+)	'The budget process occurs through the Learning Areas, and we have a program budget committee. On the committee is business manager, the finance manager, and a member of the PCO (Principal Class Officer) team. They go through every budget and say yay or nay or prune back people's wish lists. So, the budget to support digital Maker technologies goes through this same process. Part of that is ticking off the Scope and Sequence Unit plans, assessments, rubrics, and pedagogy alignment to our school instructional model'.
Technical Support (M,25+)	'There is a staff member here who keeps putting in to finance a proposal to buy a 3D Printer here. But I am on the Finance Committee and saw how they kept knocking it back and would not endorse it because the staff member didn't supply the teaching and learning, assessment, and instruction plan'.

Table 6. 4 Staff linking the use of Maker technologies to the school's standardised pedagogy

Learning Spaces

Similarly scrutinised, particularly by classroom teachers, were the learning spaces the Assistant Principal allocated for Maker technology (and all other) classes. Described by classroom teachers as 'outdated coffin spaces' (M,10+), the 'remnants of a bygone era' (M,25+), classroom 'outposts'(F,40+), and bemoaning the lack of comfort, storage, and visibility of the rooms they were allocated, and contrastingly by the Principal and her Assistant Principal as 'spare' spaces that were 'perfectly functional' (M,25+) for what the 'Elective Classroom teachers need', the Principal argued that any of the Maker technology teachers should 'consider themselves lucky to have what they have been given because the demands for space we have for general classrooms as a growing school is barely enough to serve our needs' (F,35+).

All classroom teachers were aware that student engagement with Maker technologies occurred in one of two places: the old Science block or the Senior School Computer lab, both built in the 1980s. Likewise, all staff were quick to advise that 'not a single skerrick'(F,40+) of work had been undertaken to turn either of these spaces into a dedicated Makerspace – or indeed ensure the Maker technology teachers could most effectively use these spaces, particularly with regard to providing sufficient storage and display cabinets for student 'work in progress' projects (see Table 6.5).

Teacher Leader (M,30+)	'The Maker subjects run either in the old Science block or the computer labs. The Science lab hasn't been renovated – it's freezing in winter and boiling hot in summer. There's an old prep room in between that I think the teachers store their equipment in on trolleys that they wheel in and out of the prep room – I'm not sure – it's all a bit of a mess really'.
Teacher Leader (M,40+)	'They use old rooms that have been here for nearly 40 years – I don't think their configuration has changed or the décor. All the rooms used for coding, robotics and electronics are hidden away'.
Principal (F,25+)	'I think we've got some good spaces. Yeah. And it may be that the spaces need some tweaking or whatever but let's have a look at the kitchen. A new kitchen. For years students were learning Food Tech in an old 1950s kitchen. Now we have a new kitchen. But that has made absolutely no difference to the teaching and learning stuff that is happening in that space. This is not necessarily a criticism. But I think I think the spaces can follow the innovation. I think you can create new spaces and you end up with the same sort of teaching. So, what's the point?'
Assistant Principal (M,25+)	'I think you need to respect that there are special needs in technology spaces. But then, our teachers can do amazing things with the spaces that they already have. Yeah, I think we have got some good spaces here. Besides, no one else wants or needs them, so it's good we can use them for the Maker classes with no impact on our bottom line'.

Table 6. 5 Staff views on Maker technology learning spaces

Offering an alternative view that expressed deep concerns about the school's lack of capital investment in the learning spaces used for Maker technology subjects, two classroom teachers and one Teacher-Leader made clear their awareness of link between spaces and the future viability of Maker technologies elective subjects in the school (see Table 6.6).

Teacher Y9 Electronics (M,15+)	They run it all in the old science rooms and computer rooms - the back blocks of the school. I said to my learning area leader, how are kids going to know this stuff is happening? How are they going to see other kids engaging in this stuff? For it to take off, we must make sure all kids and teachers can see kids playing and having fun with tricky stuff so other kids will go home then come back and say, you know what, I want a piece of this stuff too – we have to make it visible.
Teacher Y10 Robotics (M,30+)	If you want people to do this - you can't lock the stuff away – if the other kids could see those robots that the Year 10s are Making - you just watch them lining up at the door – boys and girls- to do robotics. They love it this stuff, they absolutely love it.
Teacher Leader (M,5+)	I think there needs to be dedicated spaces for this stuff – I think this is essential for the digital Maker technologies to succeed – a dedicated space means kids would know when they go in there, they can play, and learn, and find out about stuff – but in a safe spot. They can also feel confident knowing they can access resources at point of need rather than having to waste time and effort going to find stuff out or cramming it in some back cupboard.

Table 6. 6 Connecting spaces to Maker technology subject viability

Supporting the use of Maker technologies in Greenfield College

Regarding the types of support provided for teachers or students using Maker technologies in the school, all staff commented positively about the responsiveness and expertise of the Technical Support team. Yet in this area, the views put forward by Principal yet again proved antithetical to classroom teachers using Maker technologies. Here, the Principal's lack of knowledge about what was actually going on within classrooms was made clear insofar she affirmed her belief that 'for the tech boys just maintaining the equipment is a struggle – and it's not cheap equipment – so I know it's a challenge for them' (F,35+), whilst all other staff confirmed not only the relatively hands-off approach adopted by the Technical Support team when it came to trouble shooting problems with Maker technology equipment but also the reality that the classroom teachers of Maker technologies more often than not would work together to trouble-shoot every issue (technical or otherwise) that may arise in their classrooms on a day-to-day basis (see Table 6.7).

Teacher Y7 Coding (M,10+)	'The boys from tech support were great – whenever I needed help, I got it. They installed *SCRATCH* on all the school pcs because we had too many issues for kids logging in on their own devices. But, other than that, I mostly figured things out for myself, sometimes bringing in the other Coding classroom teachers if things got sticky'.
Teacher Y9 Electronics (M,25+)	'The tech guys are pretty good – but we mostly handle things ourselves. We're pretty self-sufficient; always have been'.
Technical Support (M,25+)	'We don't have anything much to do with helping the teachers with the robotics or the coding they have to look after their own equipment and needs. Although if they need some help with software or they use a computer that needs fixing then that will come to us. For example, we installed all the software for *SCRATCH*. Otherwise, there's no real increase in maintenance for those computer labs for us'.
Technical Support (M,30+)	'Teachers run things pretty much themselves – some teachers come to seek advice re physical computing – but not enough ask about what could be or how they could grow the kids' experiences –they never ask us that'.

Table 6. 7 Supporting classroom teachers of Maker technologies in the classroom

This notion of self-sufficiency also extended to classroom teacher views about Professional Learning. Of interest here was that the Teacher-Leader who was responsible for leading the professional learning of all College staff could provide no examples when classroom teachers of Maker technologies had been offered and/or attended professional learning sessions to upskill their knowledge or skills. Rather, as another Teacher-Leader stated, 'professional learning in this place requires you to find out stuff for yourself, in your own time'(M,10+), a notion confirmed by virtue of each of the seven classroom teachers interviewed in this study indicating their common use of 'each other or playing with the [Maker technology] to figure out how it works then teach it' (F,40+) because to 'develop our own skills to learn about using Maker technologies we have to find out about stuff in our own time and often attend at our own cost' (M,30+).

The standardised pedagogical approach to teaching and learning

The second research question explored by this study also concerns how pedagogical factors associated with teaching and learning shape student engagement with Maker technologies in the school. Of all the topics discussed as in this phase of the research, it was the school's standardised pedagogy that evoked the most emotion in Teacher-Leader and classroom teacher responses.

It soon became very clear from what was said during most interviews and informal conversations with Teacher-Leaders and classroom teachers that the Principal of Greenfield College would not compromise her view that all teachers across the school – no matter the subject they were teaching – should adhere to the school's standardised model of curriculum planning, assessment design and

standardised pedagogical approach that she brought into the school when its 'Era of Excellence' began. Equally, it very quickly became apparent that this requirement was a source of considerable tension for some Teacher-Leaders and the Junior School classroom teachers of Maker technologies.

In this regard, all Junior School classroom teachers pointed to the Principal's lack of appreciation for the differing pedagogical model needed to facilitate alternative learning experiences with Maker technologies. Here, one Teacher-Leader and all classroom teachers were well versed in the alternative teacher dispositions, practices and priorities required to teach successfully with Maker technologies (and digital technologies more generally) (see Chapter 1).

Junior School classroom teachers were emphatic about the need to create space for students to embrace productive failure and for teachers to shift themselves away from the centre of teaching. Regarding pedagogy, each also emphasised the need for student to engage with more project based and formative assessments, with each placing a greater focus on the process rather than product of learning. Equally, Junior School classroom teachers shared the view that one of their biggest struggles was to develop student appreciation for the journey rather than the result, as 'they are all in a mad rush to get their grade, their score at the end, rather than taking the time to enjoy the little tasks that get them there'(F,40+). In addition, all Teacher-Leaders and classroom teachers also added how they wished they had time to 'reach out and rebuild the active partnerships the school had with the local feeder primary schools that were active in the 1970s and 1980s – but had somehow been lost –in the 1990s'(M,40+).

More specifically, Junior School Coding classroom teachers were quick to point to the tensions they worked through every day regarding the school's expectations of curriculum planning, instruction, and assessment, and what they knew to be 'best practice' in how Maker technologies should be taught across Years 7-10. Here the Principal (F,35+) was adamant that no teacher was exempt from her school wide application of her standardisation of pedagogical model:

> 'Teachers of Maker technology electives are no different from others in the school. When writing up curriculum, they have to fill in exactly the same documentation as everyone else - using our universal curriculum templates - and provide student weekly planners to the students that clearly outlines what the learning goal for every lesson is, what the success criteria are, what HITS (high yield teaching strategies) they will use and what assessments the students will sit and when'.

Described by one Year 7 Coding classroom teacher as an 'impossible one-size-fits-all nightmare' (F,40+) another explained on behalf of her colleagues:

> 'we are not like the rest of them. To deliver this stuff well – we must let kids have free reign to explore, play, make mistakes and think – how the hell are we supposed to write that into a unit planner? Just trying to do this stuff in a single 50-minute lesson is a struggle enough!'

Maker technologies and the problem of assessment and reporting

Similarly causing considerable angst amongst Junior School classroom teachers was the Principal's assessment directive which mandated all teachers across the College report frequent marks and grades to parents garnered from a combination of tests, projects, and – in the Middle School – Semester examinations. For classroom teachers of Coding Maker technologies in the Junior School, this meant teachers felt 'forced' (M,10+) to design assessments that did not consider the 'different style of learning' associated with Maker technologies. In rationalising her push for this intensive assessment regime, the Principal (F,35+) once again pointed to her determination to ensure that

> 'every student receives a guaranteed curriculum – that is, all students – across all subjects- must be guaranteed the same learning experiences, which deliver the same learning outcomes, which are assessed using the same assessment tasks, at the same time, marked with the same assessment criteria. There simply is no room for ifs, buts or maybes – this is a school requirement'.

Clearly demonstrating the impact of the Principal's mandate that they entire school deliver a standardised pedagogy and reporting regime was having on classroom teachers of Maker technology classes was the considered view offered by one Year 8 Junior School classroom teacher (M,20+):

> 'I think maybe the fit of this stuff with the culture of the school isn't right. I think the clash between us and what goes on in other classrooms can be tricky for kids because they must navigate coming out of these classes and the way we do things here with what they are expected to do - and are expecting their teachers to do for them - in the traditional subjects. And yeah, the school's whole focus on marks, grades, and the need to get it right or be told how to get it right – I think that's massive problem for kids as they go up the school. They aren't big risk takers here – and they need to be with this stuff'.

6.3 Perceived barriers to student engagement with Maker technologies in Greenfield College

Regarding the barriers that staff perceived as impacting the uptake of Maker technologies in the school, staff responses again revealed a clear divide between the Principal and classroom teachers. Fundamental here was the Principal's view that student lack of engagement with Maker technologies

was a problem of teachers 'not being up the job' (F,35+) rather than the suite of institutional, pedagogical and leadership factors identified by both classroom teachers and some Teacher-Leaders. Here the Principal appeared committed to the view that it was the deficits of 'risk-adverse' teachers who were unwilling to 'lift their eyes to the horizon of what could be' or 'demonstrate the will to fit the Maker technologies into the school curriculum' that posed the greatest challenge to the successful implementation of Maker Technologies in Greenfield College. Here, the Principal (F,35+) particularly argued that many of the school's teachers either lacked the confidence or were

> 'Unwilling to let go of recipes. And I don't just mean a food recipe – but whatever their recipe for teaching is. We also need to encourage our teachers to allow the kids to be the designer of their own learning experiences in a responsible way. You know, in a way that fits with our budget and all the constraints teachers face … So, for me it's how does the school leadership - me and others – communicate, support, and unleash a vision of creativity amongst our staff?'

In this regard, classroom teachers of Junior and Middle School Maker Technology classes, and Teacher-Leaders, again pointed to the Principal's inflexibility and lack of understanding – or willingness – to more fully engage with the broader benefits that student engagement Maker technologies could bring to students – and indeed the school more generally (see Table 6.8).

Teacher Leader (M,10+)	'There's not a school wide focus here on this stuff – and there's a lack of understanding across the school about how the Maker mindset cross fertilises with other sorts of learning. I guess it's a case of they don't know what they don't know because so many here - especially in leadership - have been here for such a long time'.
Teacher Leader (M,30+)	'The school is pretty set in its traditional way of doing things. For the digital Maker technologies to work here, the leaders need to realise that we need to find a way to join the creative with the practical – it's not all about coding or all about design – it's a partnership. This means they need to also shift the focus away from the academic – from exams – from results. But the leaders and teachers here are conservative – they don't like change'.
Year 7 Coding Teacher (F,40+)	'Leadership here needs to be more open to experimenting with new types of learning. They need to be more open to going out and finding out about this stuff. The school needs to stop treating itself as an island, I think. But then you have to have leaders who want to know or want to challenge the way they lock down the kids learning here. Right now, I really don't see that happening given the emphasis on grades and scores and ATAR'.
Year 8 Coding Teacher (M,20+)	'The instructional model pushed by the leadership doesn't help – it's so restrictive- it's so black and white – it's so narrow- it locks kids away. There's been no discussion about how restrictive it is – how it tightens the noose around kids wanting to know the answer. There are far too many kids here that are too scared to engage, they just want to be spoon fed – they don't want to think for themselves'.

Table 6. 8 Perspectives of barriers preventing successful use of Maker technologies

In addition, all classroom teachers also pointed to the pragmatic issue of 'being kept out the loop when students were Making subject selections' for future career pathways wherein the school's career advisors (often Year level coordinators) have 'no idea about what we do with the Maker stuff or its links to pathways'(M,30+) and 'don't think to ask us for advice'(M,25+) because 'they've been told to push kids into subjects that score the highest marks'(F,40+).

6.4 Girls' use of Maker technologies in Greenfield College

Regarding the present study's third research question concerning girls' engagement with Maker technologies in the school, both the Principal and her Assistant Principal proposed girls' lack of engagement with Maker technologies could be attributed to boys being more 'naturally' (M,25+) inclined to do Maker technology subjects because 'computer science and engineering has always been a subject better suited to boys' (M,30+). Reflecting teacher views reported just on than two decades earlier, 'all the boys seem to really like the computers, and not too many girls are really keen' (Bryson & De Castell, 1998, p.559), the Principal went on to further suggest girls' disinterest would 'most likely be because the technology and the subject itself was gendered' (F,35+) and 'girls feel too intimidated to do these elective subjects' (F,35+).

These notions of technology subjects being 'gendered', also described by Bryson and De Castell's (1998) study of technological innovation and gender (in)equity in elementary schools outlined in Chapter 2, were echoed by one Teacher-Leader (F,35+) who recounted in considerable detail how she had led a small Equal Opportunity (EO) committee to 'degender' Maths and Science subjects across the school in the early 1990s because 'girls were not enjoying the same opportunities as boys' (F,35+) and there were 'very clear divisions of boys and girls in Maths and Science' (F,35+).

Here this Teacher-Leader (F,35+) fondly explained that fundamental to these 'EO walks' was the way members of her Equal Opportunity committee (EO) – including the current Principal (then a Year Level Coordinator) - spent more than a year gathering 'data' that they would later use to action their EO committee agenda:

> 'We just went into classrooms from Year 7 to Year 12 to do tallies of every time a boy spoke up, every time the girls spoke up, how much attention the girls received, how many questions the teacher answered for the boys and how many questions are answered the girls. All this data fed into an acknowledgement that yes, the school did have inequality, and yes, there was a problem that, for the sake of the girls, we had to address. Many of the girls reported not feeling safe, I don't mean in the physical sense – more the emotional and psychological' (F,35+).

Continuing, the Teacher-Leader smiled as she recalled how the EO team would visit classrooms and 'put the blokes in their place' by working with them to 1:1 to develop and deliver a series of initiatives, programs, policies and ongoing staff conversations 'like focus groups' that were 'significant in terms of shifting the 'gendered' culture of the school' (F,35+). Documents located in the school's archives revealed that these initiatives at Greenfield College included bringing to the classroom teacher's attention that they were treating the girls and boys differently in their classes and ensuring both students and teachers across the school completed EO workshops. Additionally, single-sex Physical Education, excursions and other events were operationalised to 'protect the interests of girls' (F,35+).

Inside the classroom, curriculum resources were scrutinised and rewritten to remove materials promoting gendered stereotypes – including textbooks. Further, career nights for girls and their parents were held monthly wherein 'women from all fields were brought in to speak to the girls and their families' (F,35+). This focused program of EO Interventions came to an end in the late 1990s, as did the Teacher Leader's EO role, as 'it was not needed anymore because people thought well, we've done that - It's fixed - big tick - we've fixed the problem - move along, nothing to see here!'

6.5 Summing up and looking forward

This chapter has provided a glimpse into how 19 staff members working in Greenfield College understood Maker Education and the use of Maker technologies in the school. Whilst in Chapter 5 we learned how Greenfield College has progressively worked to set itself apart from its local neighbourhood and develop its reputation as a high-performance academic school of choice, in this chapter we explored how the school's historic and everyday institutional and pedagogic conditions shaped staff perceptions of Maker technologies and the situational constraints they perceived influencing student engagement with Maker technologies, particularly girls.

Across all staff members, there was a shared positive perception of the 'novelty effect' (Philip & Garcia, 2015) of Maker technologies in the school. That is, when bringing in Maker technologies to the school, there was no need to consider improving instruction, the learning environment, or specific contextual affordances of the device, because deterministically Maker technologies will enhance student learning and cognitive development (Halverson & Sheridan, 2014; Martin, 2015). Tied explicitly to this view was the broadly accepted view across staff members that engaging students with Maker technologies would assist their '21st Century skill development'.

Yet largely absent from staff member views of the benefits of Maker technologies was consideration of the social or collaborative benefits outlined by Pepper et al. (2015a, 2015b) and Vossoughi and Bevan (2014) in Chapter 1. Instead, beneficial characteristics more closely associated with a neoliberal market agenda and its focus on the individual were suggested, including fostering an individual student's creativity and capacity to innovate (Halverson &Sheridan, 2014), or develop an individualised entrepreneurial manner (Greenberg et al., 2020).

Regarding how Maker technologies entered the school, with the exception of the Principal and Assistant Principal, all other staff members suggested there was no 'careful inclusion of Maker technologies' (Cohen et al., 2017) but rather the process of entering the school was 'haphazard' or 'ad hoc'. This disconnect between leader and classroom teacher perceptions accords with Monahan's (2001) view that teachers are marginalised from decision making processes about bringing a technology into a school, and the view of other early Educational Technology scholars (see Chapter 2) that classroom teachers were rarely invited to participate in plans for how technology will be implemented (Cuban, 1986; Peck et al., 2016). Here Peck et al.'s (2016) warning that 'excluding school constituents in planning and design' makes it difficult for technologies to 'gain traction and persist' appears relevant to Greenfield College. So too is the work of Philip and Garcia (2015) outlined in Chapter 2 which argues for schools to avoid 'haphazardly' integrating technologies and instead spend more time considering the 'hurdles' and 'institutional challenges' prior to implementation. For classroom teachers of Maker technologies at Greenfield College, this sense of exclusion included 'being kept out the loop when students were making their 'subject selections' for future career pathways despite the school's career advisors having 'no idea' about Maker technologies and tendency to 'push kids into subjects that score the highest marks' at the behest of the Principal.

This chapter has also revealed that neither the Principal nor Assistant Principal of Greenfield College considered it necessary to set up dedicated spaces for students to engage with Maker technologies in the school. Instead, Junior School and Middle School classes were allocated two of the oldest rooms in the school, both located on the 'outskirts' of the main teaching and learning hubs. Here the Principal argued there was no point investing in dedicated makerspaces because 'the space can follow innovation' whilst the Assistant Principal maintained 'no one else wants or needs [these spaces], so it's good we can use them for Maker classes without impacting our bottom line' before adding, 'Maker technology teachers should consider themselves lucky they have these spaces to use.'

These dismissive views of the importance of space suggests neither school leader was concerned about how the allocation of these spaces, or their material condition or location, impacted upon the scope of social practices that could be enacted within (Poromaa, 2017). Conversely, classroom teachers unanimously described their allocated rooms in a consistently derogatory manner, including 'outdated coffin spaces', the 'remnants of a bygone era' and classroom 'outposts', thus clearly indicating their awareness of the politics at play. Smith et al. (2016) affirm that such tensions and discord associated with the allocation of space and spatial practices are 'complex, changeable, discursively produced, and imbued with power relations' (Smith et al., 2016, p.590), whilst Tupper et al. (2008) and McDowell (1999) similarly suggest we should conceive of place making as a system of power relations that determines who belongs to a place and who is excluded by defining socio-spatial boundaries (Tupper et al., 2008; McDowell, 1999, p.4). For the purposes of the current study, Soja's (1989) view is also particularly instructive insofar he warns how 'normalised' power relations if left unquestioned – such as the Assistant Principal allocating the Maker technology classrooms – can render people mute to the production of dominant power relations.

Expanding our consideration of power in relation to all institutional structures, practices, processes, and protocols discussed by staff members in this chapter is Tyack and Tobin's (1994) 'Grammar of Schooling' and Hodas (1993) who argue for schools to consider the social, cultural, and political attributes of schooling when seeking to implement new technologies in schools. More specifically regarding gender, McGregor (2006) further points to our consideration of the 'rhythms' of the school timetable and its constraints within a 'repetitive cycle', especially when examining how gender relations are performed and remade over time. This broad lens of consideration of the 'grammar of schooling' – is instructive when juxtaposing Greenfield College classroom teacher concerns over the timetable 'strangling' opportunities for SEAL girls to engage with Maker technologies beyond Year 8, and the Principal's concession that despite some timetable limitations, no changes would be made to the timetable because the school's priority is to deliver its 'high performance' accelerated learning program to SEAL students. Helping us link the school's timetable, the Principal's prioritisation of her SEAL program and understandings of gender is the work of Liu and Grey (2018) who argue that the relationship between space and gender is best understood as an evolving construction that is constantly interacting with political, economic, and historical forces, which - in the case of Greenfield College - relates to biological categorical understandings of gender infusing the market agendas of neoliberalism.

As already suggested, the presence of these liberal essentialist notions of gender in Greenfield College are not new. This is made clear by the 'gender monitoring' activities described in this chapter which firmly implicate the historic presence and influence of liberal feminism's 1990s project of affirmative action politics in the school. Here, the Teacher Leader's recollection of leading her EO Committee (including the current Principal) undertaking a range of 'degendering' activities in the school, including scrutinising curriculum and assessment resources, textbooks, the identification of male-dominated teachers' daily practices, running EO workshops for teachers and students, and bringing in successful women to inspire girls to take up STEM careers, does much to help us understand the prevalence of fixed biological essentialist understandings of gender amongst staff members, especially staff member propositions of the barriers responsible for girls' lack of engagement with Maker technologies (and STEM) in the school.

Revealed from this chapter too is that it was only the female Principal and the one female Teacher-Leader who used the language of 'degendering'. Other understandings of gender surfaced throughout this chapter included the 'problem' of boys being more 'naturally' inclined to do Maker technology subjects because 'computer science and engineering has always been a subject better suited to boys', or because 'technology and the subject itself is gendered'. Also put forward in this chapter is the idea that girls feel 'too intimidated to do these elective subjects', too 'scared to be in a class with boys' and that girls' lacking confidence when using Maker technologies also fed into their 'unwillingness to subvert the negative stereotypes associated with taking up the 'hard sciences''. In this regard, the suggestion by the one Teacher-Leader that girls need to feel 'safe' enough to engage with Maker technologies within the context of their being a 'critical mass of a large group of girls to offer each other mutual support' suggests both biological essentialist, social constructionist liberal feminism understandings of gender associated with affirmative action.

Yet, as Chapter 3 has outlined, feminist scholars across the fields of technology, education, policy, and organisations have long problematised these simplistic explanations for girls' lack of engagement in STEM subjects or career pathways. For example, Singh (1993) argues that social constructions of male expertise and accompanying 'deficit' models of girls' position girls into powerless relations, whilst Schofield (1995) suggests that the idea that technology is a male domain is socially constructed through a school's institutional and pedagogic conditions. Problematising liberal feminism's 'gender monitoring' affirmative action agenda and efforts to 'fix' the gender inequity problem by 'gender washing and painting pink' (Heybach & Pickup, 2017) institutional and pedagogic structures of

schools, feminist scholars have instead questioned why girls are maligned as deficit (Wajcman, 1991; Lageson, 2015) and refused the notion that the 'problem' of attracting girls to STEM can be easily solved simply by making STEM pathways more accessible to girls or informing and encouraging more girls and women to 'make their way' into these areas (Lageson, 2015; Heybach & Pickup, 2017).

Particularly relevant to the understandings of gender surfaced in this chapter is Connell's (2013) argument that historic social constructions of gender associated with liberal feminism's affirmative action agenda have worked in institutions – including schools - not to 'fix' problems of gender inequity but rather 'mute' the problem. Further, Connell (2013) argues if a contemporary school does not question the historic social structures that made possible issues of gender inequality in the 1990s that were subsequently identified and allegedly 'fixed', then it is highly likely that these very same social structures and processes of schooling are still actively working to consolidate – and indeed perpetuate - gender inequity because they remain embedded and interwoven undisturbed in a school's social structures and schooling processes. Thus, still relevant to this present study is Faulkner's (2001) reminder for researchers to consider both the 'situatedness' of girls' use of technologies in schools and scrutinise the liberal feminist campaigns enacted by the State to increase the girls' participation in STEM subjects and/or career pathways as each works to simply 'gender wash and paint pink' fixed biological essentialist notions of gender that have long been knitted into the organisational structures of our schools.

This is particularly given these same biological essentialist categories of gender continue to undergird the postfeminist and neoliberal feminist notions of gender all staff members expressed in this chapter in one form or another, albeit unintentionally. As outlined in Chapter 3, these biological essentialist categorisations of gender undergird the neoliberal market agenda found deeply embedded in today's schools (Lipman, 2011). These characteristics include neoliberal notions of efficiency, de-regulation, competition, standardisation, individualisation, success, excellence, and a culture of accountability and performativity. In this Chapter, classroom teachers identified as central barriers to student engagement with Maker technologies the Principal's 'top-down' accountability measures for teachers and her insistence that all staff across the school engage in a frequent assessment regime, including common standardised tests irrespective of subject, to drive her high 'performance' school culture wherein 'learning' is understood to mean a student's performance on a test or exam (Lipman, 2011). Moreover, staff members using Maker technologies took issue with the Principal's requirement for all staff to use a standardised pedagogical model to deliver a guaranteed viable

curriculum across all subjects in the school. Each instance exemplifies not only how characteristics of the neoliberal market agenda inform the institutional and pedagogic conditions of Greenfield College, but also the largely invisible presence of binary categorisations of gender that feminist scholars have been arguing for several decades enables gender inequality to thrive.

Looking forward

In the two observations chapters that follow, I outline my classroom observations of nine classes of students using Maker technologies in Greenfield College. In this last phase of fieldwork, I report on just over 130 hours of classroom observations. These observations take place daily over a ten-week period. My purpose here is enrich the story of girls' engagement with Maker technologies that we have developed thus far by including my observations of girls' engaging with Maker technologies, and the social world they inhabit, including historic, material, spatial, institutional, and pedagogic conditions, and how interactions between students, the students and the teacher, shape or influence girls' engagement with Maker technologies. Chapter 7 outlines my observations of Junior School Maker technology classes (Years 7-8), whilst Chapter 8 provides an account of my observations of Middle School Maker technology classes (Years 9-10).

Chapter 7. FINDINGS III –Maker technologies in Junior School classrooms

This chapter outlines findings drawn from the final phase of Fieldwork: Phase IV – Classroom Observations. Its aim is to provide Thomson and Hall's (2017) 'blades of grass' (p.13) view of students engaging with Physical Computing and Programming Maker technologies in Greenfield College. Here my classroom observations offer up narratives that compete, contradict, and sometimes agree with the perceptions offered by staff members in Chapter 6 and the Maker Education scholarship outlined in Chapter 1. In both Chapter 7 and Chapter 8, my aim is to make sense of 'what is actually going on' (Aagard, 2017) regarding girls' engagement with Maker technologies. In sum, both chapters aim to contribute micro level descriptions of girls' engagement with Maker technologies in the classroom to the macro and meso levels offered in earlier chapters.

7.1 Overview – Maker technologies in Year 7 and Year 8

Two classes of Year 7 Coding and two classes of Year 8 Coding were observed for a total of 15 hours each (60 hours in total) from October to December 2018. Delivered as a one-term 'compulsory' elective subject, 'Coding and Algorithms' (Coding) was first introduced at Greenfield College at the beginning of 2018. As mentioned in Chapter 5, this represented in situ the school's mandated requirement to deliver the Victorian Digital Technologies curriculum across Years 7-10 from the beginning of 2018. For Greenfield College, this meant that for the very first time since 2006, the 2018 Yearbook – published in November - featured a photograph of an almost equal ratio of Junior School girls and boys engaging with Coding Maker technologies to promote the school's digital technologies department rather than only boys from the Year 10 Robotics class, which had been the habit for more than a decade.

Throughout my observation periods, the Year 8 Coding classroom teachers variously advised they thought introducing Maker technologies as a compulsory short-term elective was an 'okay' (M,30+) but insufficient first-step response to encouraging more students to take up technology-based subjects as it was 'better than nothing like it has been in the past' (M,20+). Reflecting after one of her Year 7 Coding classes, the Year 7 Coding teacher who was in the end-stages of her career explained she really liked teaching the course because 'it gives [her] a chance to do something different from teaching Science which is what I've taught at this place for more years than I can remember' (F,40+). Mutually shared by all Junior School Year 7 and Year 8 Coding classroom teachers

was the view that after three-terms of delivering the same course, the team felt confident teaching the Year 7 and Year 8 Coding classes in Term 4 because all had delivered the same course (including assessments) on three previous occasions (Term 1, 2 and 3). In this regard, the classroom teacher of Year 7 Coding exclaimed, 'that means I will have taught just on 100 of the 200 Year 7 students by the time I'm done this year!' (F,40+).

Drawing upon his timetabling experiences on one occasion when debriefing with me after class, the Teacher-Leader of Digital Technologies reflected upon the problem of the existing timetable structure driving student engagement with Maker technologies at the school. Here, he mused, 'I'm just thinking through how the timetable blocking works here …. I reckon there would only be a small handful of Year 7 and Year 8 students who will miss out. Yep, I think we catch everybody … And if any of the kids do miss out,' he went on, 'it would be because of extended student absences usually caused by illness or extended family holidays'(M,30+).

In sum, all Year 7 and Year 8 classroom teachers reported feeling 'okay'(M,20+), 'pretty good'(M,30+) and feeling 'no drama'(M,40+) about teaching the new Year 7 and Year 8 Maker technology courses. This they attributed to the good-humoured support of their Learning Area Leader and the way their 'crew' of colleagues had collegially 'whipped up a decent'(M,30+) Coding course using the document templates that 'the school made us use' (M,10+) at the end of the previous year. Here one classroom Year 8 Coding teacher also mused 'we ended up with a realistic, not over stretched' course that is 'straightforward, well sequenced', very 'doable' for us all (M,30+).

Also ensuring classroom teacher delivery of the new course was 'relatively painless for us all' (F,40+) another Year 7 classroom teacher told me with a laugh, 'we're all using copies of that little *Coding for Dummies* book that [classroom teacher] picked up multiple copies for us all from *Aldi* late last year!' (M,10+). This heightened sense of collegiality, good humour and indeed consistency amongst all Junior School classroom teachers delivering the same common core curriculum program, using the same method of delivery, the same assessment and the same feedback protocols was striking. Here whenever the Year 7 classroom teachers spoke about their uniform approach, comments along the lines of 'we have to do it this way, it's the way we do things here' (F,40+) were often accompanied by a wry smile and a nonchalant shrug of the shoulders.

This easy-going demeanour was particularly evident amongst the Junior School Maker technology classroom teacher 'crew' whenever they were put into a situation when they were required to

manage ‘technical misfires’ or debugging problems students were having with their programming that the Classroom teachers were unsure how to tackle. Here one Year 8 classroom teacher explained, ‘we’re not a precious mob’ and ‘none of us have an issue with showing kids we’re new to this stuff too’ (M,20+). In this sense, all seemed equally keen to teach kids that ‘it was okay not to know something immediately’ (M,30+). and that ‘students need to know that problem-solving doesn’t always happen like [noise of clicking fingers]’ (M,30+).

Last, when commenting on the spaces they were required to teach in or the lack of storage or time to engage their students with Maker technologies, the easy-going demeanour of all Year 7 and Year 8 classroom teachers of once again surfaced as each variously explained, ‘it is what it is’ (M,30+) and 'there's no point us worrying about what we can’t change – we just need to get on with it’ (M,20+).

7.2 Junior School Maker technology spaces

All Year 7 and 8 Maker technology Coding classes were observed in the same room (and its immediate surrounds) in the old computer lab located on the second floor of the Senior School building at the front of the school. This was the only computer room left in the school with a complete set of desktop computers due to the school’s shift to a student Bring Your Own Device (BYOD) program in 2015. To support the rollout of the new Year 7 and Year 8 Coding and Algorithms course in 2018 (Coding), the Technical Support team preloaded the MIT Freeware program *SCRATCH* onto all desktops in this room prior to the commencement of the 2018 academic school year. Here, my close examination of the school’s Yearbooks revealed that since this same computer lab first installed desktop computers in 2000, little had changed in the room’s configuration of desks or décor in just on two decades.

When observing the Year 7 and Year 8 Coding classes in the computer room, sometimes I waited with or adjacent to students in the corridors whilst waiting for their teacher to arrive. Sometimes if coming from an observation of a Year 9 or Year 10 Maker technologies class, I would walk with the classroom teacher through the external breezeway and up the double flight of stairs - sometimes assisting with the carrying of student work or other learning artefacts from the teacher’s desk space in the staffroom. This mirrored the path taken by all Junior School students whose lockers were also located some two hundred metres away from where their Year 7 or Year 8 Coding subject was taught.

Other spaces used by the Year 7 and Year 8 students were more makeshift in nature. These included the corridor outside the Computer lab where Year 7 and Year 8 students tested their programmed projects and/or the small Kitchenette adjacent to the computer lab, used daily by Year 12 students

to heat up their food during breaks and for a two-week period by Year 8 SEAL students to make and program their *EdCreate* 3D Printer.

The school provided no dedicated storage spaces for Junior School Maker technology students or teachers. Most often, classroom teachers stashed student work and/or Maker technologies under their desks in the staffroom. When attending class, Junior School classroom teachers loaded themselves up with student work, resources or technologies in a plastic tub, canvas shopping bag, cardboard box and/or backpack which they would then carry over from the staffroom, up two flights of stairs, into the Senior School building.

7.3 Maker technologies used by Year 7 and Year 8 students

Prior to 2018, the only experience that Year 8 students may have had with Maker technologies was through the once-per-week lunchtime Makers Club which commenced at the school in 2016 but 'fizzled out' in late 2017 when the teacher who ran it left the school. Due to a breakdown in once strong relationships with feeder primary schools, none of the Year 7 classroom teachers knew whether their Year 7 Coding students had worked with Maker technologies prior to attending Greenfield College. It was for this reason, that all 2018 Junior School Coding classes – no matter if Year 7 or Year 8 - commenced their Maker technology experience at Greenfield College by completing the same Coding coursework using *SCRATCH.* Additionally, all Junior School Year 7 and Year 8 Coding teachers agreed that using the same curriculum across Year 7 and Year 8 was wise because it was 'better to err on the side of caution'(M,30+). In this regard, my observations of both classes revealed that the single point of difference between Year 7 and Year 8 Coding classes was that it was only Year 8 students who completed *EdCreate* Robotics projects. Here a Year 8 classroom teacher explained, 'we will be running the same course again in 2019 so we don't want to give this year's Year 7 (2018) access to *EdCreate* because they'll just be repeating what they do this year. No better way to turn kids off then make them do the same stuff'(M,20+).

Both Year 7 and Year 8 Coding classes used the same freeware installation of MIT's *SCRATCH,* photocopies of commercially available resources, commercially produced worksheets and school designed standardised tests as assessment tasks. All programming work was undertaken on the school desktop computers because 'we wanted to make sure all students had equal access to the *SCRATCH* software package and have the same learning experience'. Prior to engaging with *SCRATCH,* teachers across all Junior School coding classes watched videos made by the *Khan Academy* and

Youtube to learn the theory behind Linear and Binary, Bubble Sort, and Insertion Sort Algorithms. Students then completed a set of commercially produced worksheets. When learning how to use *SCRATCH*, students across all Year 7 and Year 8 classes shared the same photocopied resources, also developed by a single commercial education supplier. Regarding assessment, all Year 7 and Year 8 Coding students were required to complete the same three tests and one *SCRATCH* project over their term-long elective course. These assessments amounted to a mixture of short-answer knowledge questions, application, and design questions.

Finally, there was no formal assessment for Year 8 students undertaking *EdCreate* robotics projects in the final two weeks of their ten-week term. Rather, as one Year 8 classroom teacher advised, 'we opted to expose the Year 8 Coding students to the *EdCreate* kit so they would have some fun playing and would get a taste of what they might do in Y10 Robotics in a couple of years' time. This might lead some to picking up the Year 10 Robotics elective'(M,30+). Shortly thereafter, this same Classroom Teacher paused before adding, 'but then again, the ones who should pick up Robotics won't because they are all SEAL kids, and in this place (points to the rooms around him), SEAL is a one-way street to doing a more concentrated dose of specialist maths and science, exceptions' (M,30+).

7.4 Observations - Year 7 Coding

10 October 2018

The girls sitting in the front row have their heads in their hands as they stare at the back cover of the test papers their teacher has just laid down before them. Immediately complying with her instruction to place all workbooks and pencil cases on the floor beneath their chairs, the girls patiently wait for the teacher to finish distributing the test to the rest of the class. The girls only lift their gaze to the whiteboard at the front of the room when the teacher writes in big blue letters – which she reiterates by voice – a reminder that under no circumstances are the students to rub out their working out or use white-out on the test.

'Remember,' the teacher calmly advises the class as she puts the lid back on her whiteboard marker, 'if you want to change one of your answers, you must first mark the spot with a circle or a highlighter, then write in your changes nearby. Then – and ONLY then,' the teacher goes on, 'should you neatly cross out your original answer so that it is still legible to me when I'm marking your work.'

Pausing for a moment, the teacher reiterates, 'Do NOT under ANY circumstances rub out your original answer. Is that understood?'

The teacher searches the room to make eye contact with all students. Satisfied all have heard her, she softens her tone to one of reassurance, 'By following this simple instruction you WILL score extra marks and CAN still score a high result even if you get the answer wrong because it's not just the correct answer we are looking for, but the way you get there.'

Almost immediately, one of the girls sitting in the back row begins to giggle, as she whispers to her neighbour, 'I didn't have time to study for this, did you?' and 'How much does this test count for anyway?' Her neighbour shrugs as she replies, 'Not sure. Does the mark go on our report, anyway?'

But there's no time for a reply. All girls in the back row are forced to quieten as the teacher approaches and lays down the test papers in front of them. As soon as the last paper is delivered, the teacher calls out, 'Remember, you have the whole lesson to complete your test. Now, turn over your papers and begin.'

Most boys – sitting sandwiched between the front and back row of girls - finish midway through the lesson. Some start to fidget with their pencils, others start doodling on the back cover of their test booklet, whilst another lays his head down to sleep as he waits for the clock to wind down and the bell to ring to end the lesson.

None of the girls in the class have finished. Instead, most still have pencils in hand, either scribbling frantically or twirling their pencils between their thumbs and index fingers; repeatedly going over what they have written.

When the teacher finally calls out, 'Pencil's down. Well done everybody! We're done!' most comply. It is only the girl in the front nearest to the window who needs to be reminded to put her pencil down. Then she, like the other girls at the front, silently slumps back into her chair as she watches all the boys quickly exit the room. Exhausted is the first word that comes to mind as I think how to describe the appearance of the front row girls.

Those in the back row also seem subdued. But it doesn't take long before they resume the rhythm of their earlier chatter. This time, however, their conversations are focused on consoling each other as they each reply with a 'no' or 'nearly' or 'no way known' or 'you've got to be joking!' to the only question that seems to matter to any of them.

'Did you finish?'

The observations outlined below relate to two classes of Year 7 Coding. In one class, there are 22 students: 11 male and 11 female. In the other class, there are 19 students: 9 male and 10 female. There are two Year 7 Coding teachers, one male with just over 10 years teaching experience at Greenfield College (Male,10+], the other is a female teacher who is close to retirement. She has been

Science teacher and Learning Area Leader of Science earlier in her career for many years at Greenfield College. She has been working at the school for just over four decades [Female, 40+].

The semi-retired teacher of both Year 7 Coding classes was comfortable teaching the newly developed course. This she made particularly clear midway through my scheduled observations. On this occasion, the classroom teacher had just finished using the old desktop computer at the front of the room, hooked up to the Electronic Whiteboard to show students how to make circular rather than straight line shapes using *SCRATCH*, change the standard *SCRATCH* 'sprite' to a pencil, and change the background. As she logged off and the students filed out of the room, the classroom teacher caught my eye and chuckled before saying, 'so even though I've got more than one leg out the school gate,' a reference to her imminent retirement, 'this [pointing to the whiteboard] just goes to show, you CAN teach an old dog new tricks! Tell that to the young ones who think us older folk can't figure out how to do tech!' (F,40+).

Throughout my observations of this teacher's Year 7 Coding class, I noted how her teaching approach appeared to be less on 'how to do tech' and more of 'how to go about it'. Not long after her students finished their first test, the classroom teacher explained to me that she told all her students that she used the 'little book *Coding for Dummies*' to teach herself *SCRATCH*. Moreover, that on the few occasions she had been unable to answer student questions in any of the classes, she purposefully modelled a simple trouble-shooting process that she hoped the Year 7 students would emulate: first, she would openly ask a student in the class 'who got it' for advice; then, she would work with the student who asked for help to search the *SCRATCH* Web HELP notes or *Google* for advice; or, if neither of those strategies worked, she would tell the students she would ask one of the other Coding teachers and then report back to the class (and the student) at the beginning of the next lesson.

On another occasion, the Year 7 Coding teacher's tone became quite serious as she explained, 'it's our job as teachers to show these kids how to deal with the realities that life throws at us. The fact is that in real life, answers to problems are not – or hardly ever – laid at our feet' (F,40+). It was for this reason, she reiterated, that sometimes she pretended not to know how to do things or, 'if push comes to shove, I'll just invent a problem if one doesn't exist. I mean, I'm pretty good at this stuff now!' before going on, 'even if it's only with me, and only for one term – at least these kids will see it's okay not to have every answer to every problem at your fingertips' and, she paused, 'it's doubly okay to admit to someone that you need help finding answers, help figuring things out' (F,40+).

Thereafter the Year 7 Coding teacher's tone softened as she reflected, 'too many kids at this school fear getting low marks, especially the SEAL kids who are so damn competitive! All they care about are their grades, nothing else and that's paralysing them because all they can think about is what others will think, and what will happen, if they don't get the highest marks' (F,40+).

Year 7 Coding classes consistently commenced with all students sitting in rows of tables facing the teacher at the front. This was also the configuration used when students were undertaking tests. Across both Year 7 classes, students sat in the same positions for every class. In the case of girls, this meant occupying the front and back rows, whilst most boys sat in the middle. When I mentioned this to the Year 7 Coding classroom teacher, she said, 'oh, yes - I asked the girls about that the other day. Turns out those in the back row are smart cookies. They've figured out if they sit there, they can just swing around and 'bingo!' they are sitting out their favourite computer!' (F,40+).

Five types of learning activities were observed across the two Year 7 classes. These included: worksheets, tests, design on grid paper, using *SCRATCH* and, with teacher permission, playing Maths Games *CoolMathsGames* using the desktop computers in 'free time' – a tactic I observed all Junior School classroom teachers using as a reward to 'keep students – especially the chatty ones - on task' (M,10+).

Tests were taken very seriously by all Year 7 Coding students, particularly the Year 7 SEAL girls. On each occasion either class completed a test, I did not see one student writing in blue or black pen, despite students being 'invited' to do so. According to the classroom teacher, students at 'this school have a love affair with writing in pencil, it's really hard for teachers to get them to commit to writing in pen'. My ongoing observations across all Maker technology classes confirmed this view wherein I noted all students from Year 7 – Year 10 opted to use a mechanical pencil with a built-in eraser. Boys usually finished their tests well before the girls whilst in contrast, most girls kept writing right up until the last possible moment of each set test.

Likewise, most Year 7 Coding students invested considerable effort in their design projects, particularly the girls, and again using pencil. On several occasions, I overheard the classroom teacher say to the boys, 'have a look at the detail [insert girl's name] is putting into her design, that's what you should be doing' or 'why don't you ask [insert girl's name] to explain why she's designing hers using [insert aspect]' (F,40+). Noteworthy here too was how the girls – unlike many of the boys -

constantly used as their reference points the various resources and tasks completed in earlier lessons to perfect their designs.

Yet in many of the Year 7 classes I observed – again across both classes – it was also evident that using prior work was not the only support used by girls. Rather, there was a noticeable sense of camaraderie amongst the girls wherein I often saw individuals, pairs or small groups of girls helping each other and/or the boys. Sometimes it seemed the girls preferred to seek assistance from each other rather than the teacher; a behaviour both Year 7 classroom teachers encouraged by praising the girls publicly or one-on-one whenever they saw this taking place. These supportive behaviours contrasted somewhat to the boys, many of whom seemed to prefer to work alone or, when stuck, more quickly turned to the Year 7 classroom teacher for assistance.

As mentioned, a reward for staying on task throughout their fifty-minute lesson and/or to 'keep students busy who completed their work early' (M,10+) both Year 7 classroom teachers permitted all students to go on the *Coolmathsgames* website (coolmathsgames.com). After logging in using their school network accounts, students accessed this site using the 'School Favourites' icon. According to one Year 7 Coding classroom teacher (M,10+), it was 'pretty common for government schools to use this website' for students in Years 7-10 and 'I know here pretty much all Junior school and some Middle school students use it as a filler when kids finish their work, or the teacher is away' instead of letting kids 'watch *Youtube* videos or cruise the net for other random stuff'.

Laid against a dark background that matched the colour palette of the school's internal spaces, the *Coolmathgames* website offered students games that fell under a range of categories. Here the most popular games played by the Year 7 students fell under the categories of 'Time Management Games', 'Hard Control Games' and 'Adventure Games'. Notable in each was the dominant masculine associations in the names of games. These included weapons associated with conflict, including 'cannon', 'shootaround', and 'battle coast' and 'wars'; and masculine authority names including, 'king', 'emperor', 'papa', 'spaceman' and 'master'. Here two other games, both presented in pink graphics at the bottom of the screen, seemed to attract more girls' attention than the boys. Reminiscent of Lucinda McKnight's (2020) 'toolbox of boys' toys' on her computer dashboard screen wherein the only 'feminine' icon was 'most faintly rendered in the bottom right corner of each [dashboard] tile' (McKnight, 2020, p.509), these two *CoolMathsGames* icons located at the bottom of the screen were named, 'Papa's Cupcakeria' and 'Papa's Scooperia' (see Figure 7.1).

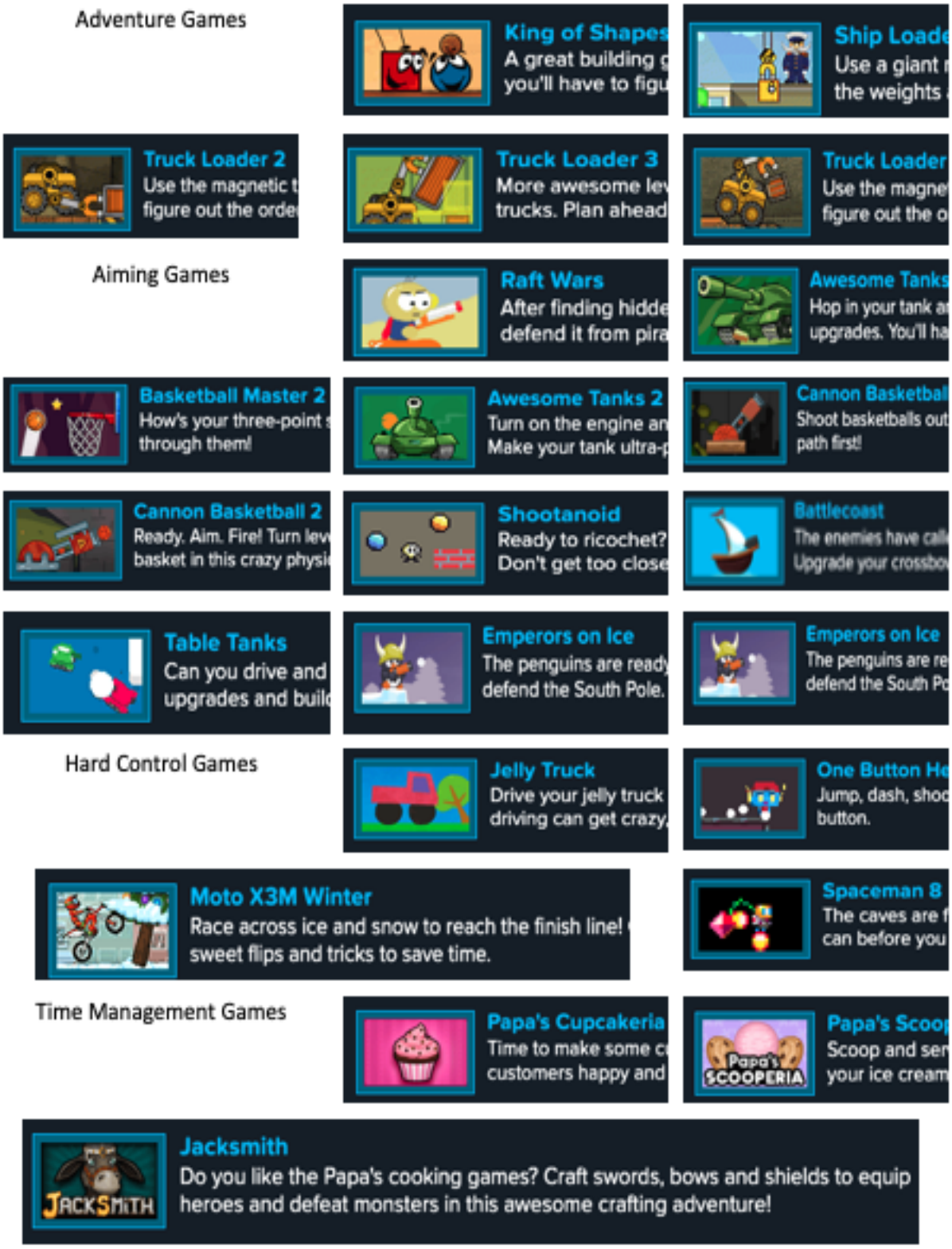

Figure 7. 1 Maths computer games played by Year 7 Coding students [Webpage Screenshot]

7.5 Observations - Year 8 Coding

27 November 2018

Lugging their workbooks, pencil cases and laptops from lockers located on the other side of the school, the Year 8 Coding students make their way over to the senior school's three-storey building. Walking well to the left of the stairwell's thick hazard-yellow paint line that keeps entering and exiting students apart, the students arrive at their second-floor classroom just as the last verse of 'Somebody told me' by The Killers plays its final chorus over the school's loudspeakers to remind students that they should be well on their way to their next class:

> *Well, somebody told me you had a boyfriend*
> *Who looked like a girlfriend*
> *That I had in February of last year*
> *It's not confidential, I've got potential …*

Whilst waiting for their teacher to arrive, the students stand respectfully next to – but do not lean against - the steel-blue Year 12 lockers abutting either side of the Computer Lab. This is the same room that has been used to teach computer programming subjects in the school for more than two decades.

Just as the music stops and the bell rings, the teacher arrives. Greeting his students with a friendly 'How are we all?', he pauses to take a breath after carrying a large postal box stuffed full of EdCreate Edison Robot Creator's Kits from his office over in the next building, then up two flights of stairs. After putting the box down on the polished vinyl floor, the teacher digs into his pocket to find his keys, then unlocks the heavy slate grey sliding door. One of the students who has been hovering eagerly at the room's entrance helps the teacher nudge - then push – the door open. Picking up the box, the teacher stands just inside, ushers the students into the room and waits for stragglers to find their seats. The quiet 'thud' of the doors sliding shut announces to all that it's time for class to begin.

Standing in front of three rows of tables, each designed to seat eight students across, the teacher waits for the students to settle before he begins to speak whilst also unpacking the delivery box that he has laid down on one of the front row desks. Realising his students are focused on what he is doing rather than what he is saying, the teacher closes the lid of the box and steps away from it. Now as he makes eye contact with every student in the room, the teacher announces that the class will use this lesson to commence work on their final coding project. Whilst initially this elicits little response, flickers of interest soon emerge as the teacher returns to the box and pulls out two bright orange Edison Robot Creator Kits. Holding the kits aloft like trophies in either hand, the teacher does his best to generate enthusiasm as he paces across the room, calling out the names of the potential projects that students will be working on - EdTank, EdDigger, EdRoboClaw, EdCrane and EdPrinter.

Almost immediately, three boys sitting in the middle row begin to jockey for project rights for EdTank or EdRoboClaw. As they wonder out loud how each works to destroy things, four girls sitting in the back row shift in their seats. One in particular appears irritated. As she puts her foot up on her seat, and defensively raises her knee, another girl mutters loud enough for others to hear, 'Here we go again!'

Up to this point, the four high-achieving girls sitting in the very front row show little interest. That is, until the teacher further explains he will be allocating projects to students according to the level of programming skills they have demonstrated in previous paper test assessments. At this point, one of the front-row girls puts down the pen she has been using to doodle inside her workbook and exchanges a knowing look with the girls sitting next to her. Soon after, each of the front-row girls is fully focused on the teacher as he announces that he is allocating the most difficult project, the EdPrinter, to the group of front-row girls and that because of the project's complexity, the girls will work independently in a private space across the hall for the next five lessons.

As the remaining students do their best to reconfigure the tables inside the Computer Lab to facilitate group work, the teacher leads the four front-row girls across the hallway to a former computer pod, now used as a Year 12 lunch-station. Purposefully redesigned to be standing room only, the tiny room provides neither tables nor chairs. However, it does offer a small unobstructed area of floor space that the girls are advised is perfect for building their project. The girls seem unaffected by the lack of furnishings. Instead, they nod in unison as they first drop their books, then themselves to the floor.

Within minutes the girls are lying on their bellies, sprawled across the rough grey-black carpet tiles, facing inward towards a common focal point. Configured like a single starfish, the girls kick their legs under the tables used to hold several microwave ovens and two electric kettles. Above them, a single fluorescent lamp does its best to make up for the lack of natural light.

Propped up on their elbows, the girls work quickly to rip open the packets of Lego that come with the EdCreator Kit. They chatter incessantly about how amazing it is that they have been given this project to do all the while maintaining their singular focus on sorting the twelve packets of orange, dark and light grey Lego pieces into like-coloured piles. Their Making space is a single central carpet-tile that lies centrally in front of them all.

As the sorting task nears completion, one girl gets to her feet and strategically positions her laptop on top of one of the two small fridges sitting in the right-hand corner of the room. After first zooming in to magnify the online instructions she downloaded whilst the others finished sorting, she positions her screen to face the group as she asks the others if they can read the instructional drawings from their relative positions on the floor. When it becomes clear the answer is no, she brings her laptop back to the floor, lies down and proposes that she help the group by navigating and reading out the construction instructions because she lacks experience working with Lego. Whilst the other girls agree, each also openly admits that they too are feeling a little apprehensive because they also lack Lego building experience.

The teacher reappears in the doorway to check on the girls' progress as the fifty-minute lesson nears its conclusion. Noisy chatter and laughter follow him from across the hall. When the girls explain their concerns, the teacher quickly reassures them they will have no trouble constructing or programming the EdPrinter providing they work together, play to each other's strengths, and use the debugging processes they have been learning throughout the term.

He then hands over a green Woolworth's shopping bag that holds an assortment of recycled take-away food containers and lids. Advising the girls to use their packing-up time to plan how they will move forward in the next lesson; the teacher reminds the girls to clearly name their green grocery bag, so they can quickly find their project amongst others that will be stored overnight in the old server room next to their classroom. As she listens, one of the girls climbs to her feet and takes out a brightly coloured hair ribbon from her pencil case which she ties to the handle of her group's bag using a big double knotted bow.

The observations that follow below relate to two classes of Year 8 Coding. In one class, there are 20 students, 11 male and 9 female. In the other class, there are 22 students, 10 male and 12 female. There are two teachers of Year 8 Coding. The two Year 8 Coding teachers are male. One has been teaching at Greenfield College since the 1990s (M, 30+), the other has been teaching in the school for more than 20 years (M, 20+).

All Year 8 Coding classes commenced with students self-selecting their seating positions in the rows of tables facing the teacher. Like the Year 7s, the Year 8 students habitually chose to sit in the same positions for each class, with the girls once again occupying the back rows, boys sitting in the middle, and the Year 8 SEAL girls consistently occupying the front row of seats closest to the teacher. Thereafter, this latter group of girls would quickly move over to use the same set of desktop computers underneath the window.

In the first five weeks of the Year 8 Coding elective, students completed the same coursework and the same learning activities as the Year 7 Coding classes. This included worksheets, tests, and project design task using grid paper which they would then code using *SCRATCH* on the desktop computer. Tests were also taken very seriously, particularly by the Year 8 SEAL girls. Again, the 'student love-affair' with pencil 'because they can rub out mistakes – these kids hate Making mistakes, and hate their work looking messy' was evident in both Year 8 Coding classes, particularly amongst girls.

Much alike their Year 7 counterparts, girls in both Year 8 Coding classes also supported one another; including peers outside their friendship groups. Both Year 8 Coding classroom teachers purposefully

nurtured the girls' collaborative relationships by constantly circulating the room, as they made sure students were on task, giving praise and assistance where needed, and encouraging the girls to help each other and coach peers who 'weren't quite getting it'. On more than one occasion, both teachers would call over students to view one student's screen so that the student concerned could showcase his or her work to the class. In response, girls in both classes would ask their teacher, 'do you want the others to come over and look at my work? I don't mind sharing if it will help them?' Here, in one class in particular, the Year 8 classroom teacher's first response was to chuckle, then reply, 'You need to tell them, not me. That's your screen, your work, not mine. Go for it!' (M,30+).

In the last few weeks of Term, Year 8 students were given the option of completing 'Extension Projects' using an *EdCreate* robotic project of their choice. Here, students were given the option to choose one of five projects, each designed to 'enrich students' STEM education experience through interactive engineering and programming projects' (blurb on the *EdCreate* instruction manual). Projects included: *EdTank, Ed Digger, EdRoboClaw, EdCrane* or *EdPrinter* (see Figure 7.2). Here the Year 8 Coding classroom teachers once again played an important role in encouraging the Year 8 SEAL girls to extend themselves, saying: 'I'm not giving you the chance to choose the soft-option here. All bets are off! You girls are going to do the most challenging project of them all, the *EdPrinter*' (M,30+). As a further tangible indicator of his confidence, the Year 8 Coding classroom teacher then quietly led the Year 8 girls out of the Computer Lab and across to small room immediately opposite – now repurposed as a Year 12 kitchenette - 'so [the girls] can spread out and get the job done, undisturbed' (M,30+).

Figure 7. 2 Robotics kits used by Year 8 Coding students [Screenshot Manufacturer image]

Over the course of the next two weeks, I focused my observations on the group of four Year 8 SEAL students, eager to see how the girls would respond to the Year 8 Coding classroom teacher's challenge. This meant I witnessed firsthand the girls' emotional rollercoaster as they 'refused to give up' and 'refused to give their teacher the satisfaction of failure' (comments made by two Year 8 SEAL girls). Without once seeking their teacher's advice, this group of high achievers delegated responsibilities, made decisions collaboratively, laughed, cried in exacerbation, and laughed again. Aside from the Year 8 Coding teacher occasionally offering the girls some basic advice as he unlocked the Year 12 kitchenette for them to set up at the beginning of each lesson, the girls were not instructed how to engage with their task nor how to coordinate its completion (see Figure 7.9).

Instead, once left alone, the girls sat cross-legged on the carpet of the kitchenette floor and opened up to each other about their progress working as a team, and the tasks or roles they were contributing to the group. The maturity shown in these self-reflective conversations was extraordinary. For example, one girl told her peers at the very beginning of their project that 'because I come from a really large family, one of my best skills is managing the temper of a room.' She further explained, 'I mean I can sense when someone needs to take a walk before they blow their stack!' The other girls quickly agreed that it was a good idea to have someone in charge to manage the emotions of the group, and the girl who brought this idea up was most definitely the best candidate.

As the girls got on with the business of Making, I watched and listened to their laughter, lots of proactive self-talk, singing and plenty of peer encouragement as each contributed – in her own way - to the building and programming of their *EdPrinter.* Here on multiple occasions their chosen emotional manager gently reminded one or more of her peers to 'chill out' or 'go for a walk then come back.' Sometimes this advice applied to all four girls, particularly when they collectively realised they would have to deconstruct their work and start over due to misreading the instruction manual or confusing one shade of grey *Lego* with the darker shade as they tried their best to negotiate the building of the *EdPrint*er using a black and white instruction manual which they displayed on one of the girls' tiny notebook computers. Here, as on other occasions, I watched the four girls methodically work together on their project, witnessing their emotions swinging from nervous trepidation to frustration to ultimately celebration, pride, and joy. No two lessons were ever the same.

In their very last lesson of the term, the girls rushed back to the computer lab, triumphantly carrying their completed *EdCreate 3D Printer.* As I followed behind, I listened to the four girls praising each

other's efforts, giving credit to the work of others or the group rather than one individual. Then as they entered the computer lab to showcase their finished product to their classroom teacher and the whole class, the teacher could barely contain his pride as he looked up and smiled. Soon after the girls' finished demonstrating to the whole class how their programmed *EdCreate* 3D Printer worked, the Year 8 Coding Teacher quietly turned to me and said, 'see what this stuff can do for kids? It's magic!' (M, 30+).

7.6 Summing up and looking forward

Several aspects related to teacher and student experiences with Maker technologies inside formal school settings canvassed in Chapter 1 were not confirmed by my observations of the Junior Maker technology classes in Greenfield College. For example, I did not witness the 'novelty effect' (Philip & Garcia, 2015) or observe Maker technologies being conceived of as a 'quick fix' (Philip & Garcia, 2015) to secure the academic and/or economic future of students attending Greenfield College, as outlined in Chapter 2. Furthermore, classroom teachers were not observed lacking in confidence (Martinez & Stager, 2013; Justice, 2016) nor did they appear concerned to seek professional development opportunities to help them teach with Maker technologies as suggested by Martinez and Stager (2013) and Koh and Abbas (2014) in Chapter 1. Rather, whilst not all classroom teachers across Year 7 and Year 8 Junior School Maker technology classes possessed the 'confidence to model and scaffold specific processes' (Peppler & Bender, 2013) associated with *Scratch* or *EdCreate* robotic projects, equally few classroom teachers exhibited concerns about removing themselves from the centre of the classroom as recommended by Justice (2016) in Chapter 1, Cuban (1986), Tyack and Tobin (1994), Peck et al. (2016) and Martin (2017) in Chapter 2, and the contemporary feminist pedagogues outlined in Chapter 3; each of whom encourage classroom teachers to 'teach differently' by reducing the distance between teachers and students, thereby encouraging gender equality in the classroom at the local level (Ylöstalo & Brunila, 2018; Belliappa, 2020).

Regarding student engagement more broadly, I did not see Year 7 or Year 8 students – boys or girls - engaging with an 'authentic audience' (Brennan & Resnick, 2012) nor were students of either sex observed developing a new 'learning identities' (Vossoughi & Bevan, 2014) as described in Chapter 1. Perhaps most significantly absent moreover was that at no time did I see or hear students – particularly girls – realising the connections between using Maker technologies and future STEM subjects or pathways (Buechley et al., 2013; Vosssougi & Bevan, 2014), or feel more 'empowered' to engage with STEM concepts and theories (Kafai, 2014; Dougherty, 2015; Gershenfeld, 2007, 2012) or

give consideration to picking up computer science or engineering STEM subjects or career pathways as a consequence of their 2018 engagement with Maker technologies. This was despite students in the classes I observed all being told – repeatedly by their classroom teachers – that the option for them to change their elective subjects for the following academic year would remain open to all students right up until the end of the 2018 academic year.

Relatedly, my observations of Junior School Maker technology classes also confirmed several points raised in Chapter 2, particularly regarding Tyack and Tobin's (1994) notion of the 'Grammar of Schooling'. For example, I did see teachers and students working in inappropriate learning spaces, doing their best with insufficient teaching time, dealing with insufficient storage spaces (Tyack & Tobin, 1994), coping with competing educational priorities (Baldwin, 2013; Hsu et al, 2017) and other aspects related to their spatial and material location (Monahan, 2001). These factors, along with the haphazard implementation (Philip & Garcia, 2015) of Maker technologies in Greenfield College that denied classroom teachers a voice (Cuban, 1986; Tyack & Tobin, 1994) did little if anything to 'alter the look-and feel' of Greenfield College (Hodas, 1993), particularly given the Year 7 and Year 8 Maker technology classes were run in a computer lab that had not changed – except for updating the desktop computers and installing a projector – for just on two decades. This meant – save for the influence of classroom teachers – student experiences in Year 7 and Year 8 appeared to maintain (if not consolidate) the power relations associated with deeply entrenched historic social practices long exercised in the existing school environment (Poromaa, 2017).

Regarding gender, my observations of the Maker technology curriculum resources used in Year 7 and Year 8 Maker technology classes revealed deficit depictions of females and/or the privileging of masculinity in curriculum resources as outlined in Chapter 3 (Bailey & Graves, 2016; Brugeilles & Crome, 2009). For example, in Year 7 and Year 8 Coding classes, students' free time was spent playing computer games that codified the primacy of 'valid knowledge' (Olson, 1989) as masculine wherein figures of masculinity not only dominated but also visually subordinated the feminine through stereotyped names, placement of images and attribution of roles on the screen of *CoolMathsGames.* Further, the only gender-neutral *EdCreate* robotics project option available to girls was the 3D-Printer; wherein all other robotic models replicated heavy machinery associated with the construction industry. Here each material entanglement reinforced the long held existing paradigm of computer technologies being the 'male domain' (Schofield, 1995) wherein the Maker technologies and computer technologies girls engaged with in Year 7 and Year 8 Coding classes became an 'agentic

force' (Kummen, 2015) of male technological expertise materially and socially positioning girls into deficit power relations (Singh, 1993; Bryson & De Castell, 1998).

Yet, my observations of Year 7 and Year 8 Maker technology classes also bore witness to all Junior School classroom teachers, at some point, making decisions to at least partially 'disrupt' (Sim, 2017) the Principal mandated (see Chapter 5) traditional teacher centred instructional practices of the school's prescriptive 'default pedagogy' (Peck et al., 2016). Thus, whilst the observations outlined in this Chapter reveal that for the most part, neither classroom teachers nor students could escape the school's cultural expectations that every class in the school would engage with the school's mandated 'default pedagogy' (Thomson et al., 2012) – including the performance requirement for all students to regularly complete 'worksheets, quizzes, [and] tests' (Peck et al., 2016) - there were fleeting moments in the Year 7 and Year 8 Maker technology classrooms where classroom teachers and students did '(re) negotiate how social relations of girls, boys and teachers are positioned by pedagogic practices inside the classroom' (Berstein, 2000). This meant in these moments, spaces were also created where the 'neoliberal educative expectations' described by (Utoft, 2020) were subverted by 'counter practices' (Sims, 2017) outlined by Shrewsbury (1997), Martin (2017), and Ylöstalo and Brunila (2018) (see Chapter 3).

Common to each of these occasions was a Junior School classroom teacher making a conscious decision to turn their back on the expectation they would apply the school's teacher centred, standardised 'default pedagogy'. Martin (2017) argues such moments also define a rejection of the notion that the teaching methods associated with the 'default' pedagogy are politically neutral acts (Martin, 2017). This was exemplified by the Year 7 classroom teacher (F, 40+) nearing retirement purposefully calling upon her students to instruct the class when she 'could not' resolve a problem to demonstrate 'it was okay not to know' and she was a fellow learner (Martin, 2017), the Year 8 Coding classroom teacher (M, 30+) purposefully setting the highest expectations in the class for the Year 8 SEAL girls by publicly challenging them to work in partnership to complete the most difficult *EdCreate* robotic kit project without his assistance, then providing them with a space set apart from the constrains of the traditional computer lab; and every Junior School classroom teacher (M, 10+; F, 40+, M, 30+, M, 20+) encouraging girls to mentor other students (boy or girl) struggling with their coding projects and publicly praising the girls' work as exemplary in front of all students.

Thus, even if only for two weeks, and only on the floor of a Year 12 kitchenette used by VCE students to heat up lunches or snacks, this chapter's specific observations of Year 8 SEAL girls quickly becoming fully engaged with Maker technologies, taking full ownership of their projects from start to finish, working in collaboration, engaging with each other's rollercoaster of emotions right up until they finally publicly (and proudly) proclaimed the success of their finished project can be understood as a moment in time when the Year 8 Coding teacher's (M, 30+) decision to engage with a 'feminist pedagogy of gender equality' (Ylöstalo & Brunila, 2018) - not that he would describe it as such - worked to both set aside the 'prohibitive social and material conditions' of gender inequality underwriting the neoliberal values promoted in the school, and make possible a spatial and temporal rupture in power relations (Ylöstalo & Brunila, 2018).

Chapter 8. FINDINGS IV –Maker Technologies in Middle school classrooms

In this chapter I outline classroom observations related to Year 9 Electronics and Year 10 Robotics. As outlined in Chapter 6, these are classes that have run in the school for more than a decade, using technologies that the school rebadged as 'Maker' to meet the school's requirement to implement the Victorian Digital Technologies Curriculum, as outlined in Chapter 3 and Chapter 5, from 2018. Noteworthy here is that of the 46 students enrolled in Year 9 and Year 10 Maker technology subjects, 6 are girls.

All three Middle School Maker technology teaches are male, and all have been teaching the same subjects – in addition to Mathematics and Science – at Greenfield College for many years. One Year 9 Electronics teacher has been teaching at the school for just on 15 years (Male, 15+), the other since the early 1990s (Male, 25+). The Year 10 Robotics teacher has been teaching at Greenfield College for just on three decades (Male, 30+).

8.1 Overview - Maker technologies in Year 9 and Year 10

Year 9 and Year 10 Maker technology electives ran for 3 x 50-minute lessons per week over the course of two ten-week terms in one semester. This was one lesson and one term longer than the Junior School Maker technology classes. However, my observation of Year 9 and Year 10 observations in Term 4 was limited to 6 weeks due to the requirement for Year 9 and Year 10 students to undertake end of Semester examinations over the two weeks in Week 8 and Week 9, then Year 10 work experience and Year 9 career counselling sessions in their final week of term. Thus, my observations of Year 9 Electronics and Year 10 Robotics amounted to 45 hours in total.

Both teachers of the Year 9 Electronics (M,15+; M, 25+) and the teacher of Year 10 Robotics (M,30+) were quick to advise they had been teaching their subjects for 'more than a decade.' This was long before the digital technologies 'we've been using in our subjects were rebranded into trendy Maker Education stuff' (M,30+). Indeed, both Year 9 Electronics Classroom teachers seemed a little bemused that I wanted to observe them doing the 'stuff we've been doing for so long' (M,15+) because 'it's no big deal, all schools do it, don't they?' (M,25+).

Although all three Classroom teachers appeared aware of the need for the school to implement the Victorian Digital Technologies Curriculum (Years 7-10), neither the Year 9 or Year 10 teachers

appeared remotely interested in what was going on in the Year 7 or Year 8 Coding classes. Instead, all appeared happy to maintain what the Year 10 Robotics teacher termed 'a degree of separation'(M,30+) between 'that trendy stuff'(M,25+) and 'what we are trying to do over here' (M,15+). This attitude may explain why no changes were made to either the Year 9 Electronics or Year 10 Robotics subjects in the 2018 iteration of the school's Year 7-10 digital technologies curriculum. Instead, the same 'why fix what's not broken' (M,25+) course of Year 9 Electronics and the 'proven and very successful'(M,30+) Year 10 Robotics courses run at the school since 2006 were run again in 2018, unchanged.

Like all other elective subjects in the Junior and Middle School, Year 9 Electronics and Year 10 Robotics elective subjects ran for fifty minutes. Unlike the Year 7 and Year 8 electives, however, both Middle School Maker technologies had one double lesson (100 minutes) allocated of the three available on each week's timetable schedule. Here one Middle School Classroom teacher [M, 25+] told me how the Middle School teachers had 'fought long and hard to get this. We used the argument that we weren't doing chalk'n'talk like other subjects. It took them awhile, but leadership finally got it and gave us the time we needed' (M,25+).

8.2 Middle School Maker technology spaces

All Middle School Maker technology classes ran in the 1980s Science Block, now unused except for these classes, located at the opposite end of the school to the Year 7 and Year 8 Coding classes. Hidden behind the 'two million dollars, state-of-the-art' Science Centre (opened in 2011), the 'Doctors On Site' offices (opened in 2016) and in front of an increasing number of brand-new portable classrooms used to cater for burgeoning Year 7 student enrolments, these spaces were otherwise pencilled in for demolition and redevelopment at some point in the near future.

Each room was minimally furnished, with not enough chairs of the appropriate height for Year 10 Robotics students wishing to work on the raised benches located on the periphery of each classroom. Both the Year 9 Electronics and Year 10 Robotics teachers seemed exasperated by the lack of heating and air-conditioning in the rooms saying, 'on those really hot days in November, like today, it's like we're the only ones working in a place that time forgot' (M,30+). All externally facing windows were also shuttered and bolted shut.

Unlike the Year 7 and Year 8 Coding classes, however, there was some storage space for the Year 9 Electronics and Year 10 Robotics classes. Here, both Year 9 Electronics teachers (M,15+; M,25+) used

an old metal cupboard to house up to twenty-five electronic kits in plastic tubs with lids, an assortment of parts and tools, and a class set of Dick Smith's (1979) *Funway into Electronics* project books. On the other side of the room, the Year 10 Robotics Teacher (M,30+) used an equally battered cupboard to store his *LEGO Mindstorms* robotics kits, a larger tub of spare parts, and a class set of well-thumbed photocopied Instruction manuals. Both classes also made use of the disused preparation space that lay between the two science rooms. This space was infrequently used by the new Science Centre laboratory technicians as a place to store old or broken experiment materials and equipment. As such, Year 9 Electronics and Year 10 Robotics teachers placed random stacks of student notebooks on an overly stacked moveable trolley or on top of other disused laboratory materials in a haphazard manner. There was no sense of order or organisation. Rather, the Year 9 Electronics and Year 10 Robotics teachers admitted they used this space as a 'dumping spot' for 'stuff that can afford to be lost'; including older or torn editions instruction manuals and any other surplus materials that they had no further use for. In the words of one Year 9 Electronics teacher, 'it's all a bit of a disaster zone really, but who has time or the energy to sort it out? I just make sure that what my kids need is kept in the locked cupboard'(M,15+).

8.3 Maker technologies used by Year 9 and Year 10 students

Much like the Year 8 Coding students, the only opportunities Year 9 Electronics or Year 10 Robotics students had to use Maker technologies at the school prior to 2018 was through the once-per-week lunchtime Makers Club. According to both Year 9 Electronics teachers and the Year 10 Robotics teacher, this lack of exposure to the 'technical skills they required' was the main reason the school introduced the 'really basic Dick Smith (1979) *Funway into Electronics* kit in Year 9' (M,25+) and a 'slightly more complex yet still accessible' *LEGO Mindstorms* Robotics Kit in for students in Year 10 (M,30+).

8.4 Observations - Year 9 Electronics

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The blinds are closed, and the lights switched off. Except for the two boys standing behind the raised teacher demonstration bench at the front of the room, the rest of the class sit on high stools in groups of five or six around four large square work benches: their bodies more or less facing the large pull-down screen at the back of the room. While they wait for the teacher to finish taking the roll and commence his 'A Brief History of Electronics' presentation, the students keep themselves amused quietly playing games or watching YouTube videos on their laptops or iPad.

Sitting over near the windows at the front of the room, two girls sit close together. They share a set of earbuds to listen to something playing on one of their laptops. Nearby, a boy appears lost in thought as he absent-mindedly yet expertly flicks then rotates the two-toned fluorescent yellow, orange, and green squares of his Rubik's Cube. On the other table close to the front, the only other girl in the room sits in amongst a group of five boys, sketching what appears to be a Manga figure. The boys largely ignore her, and she seems content to reciprocate. Sensing the class is about to begin, the girl closes her sketchbook and folds her arms as she leans on the table.

Then, like the rest of the class, she watches the teacher load up the student 'Score Card' on the large television screen at the front of the room. All listen attentively to the teacher's reminder that this is the last time he is allocating 'bonus points' to students who answer quiz questions throughout his presentation and/or complete extra projects from their 'Dick Smith' project manual.

The girls at the back remove their ear buds and quiet falls over the room as the teacher begins by describing how John Bardeen, William Shockey and Walter Brattan created the first transistor. All twenty-two students in the room listen carefully as he continues, some taking notes. The next slide follows with an infographic and explanation of how transistors work. Then without warning, the room erupts as a bright red 'Quiz' slide flashes up on the screen. 'When was the first transistor created?' it asks loudly in extra-large font.

Instantly a sea of hands pumps the air as students around each table clamour to be picked by the teacher to answer the question. It makes no difference when the teacher calls out, 'Too easy! I'm only going to give one bonus point to the correct answer of this one. Who wants it? You can have it to warm up!'

Over the next forty minutes, the class appears to settle into an easy, well-rehearsed rhythm of 'explain - focus – quiz question - score' as the class continues to learn about more famous inventors in the field of electronics. The teacher continues to add points next to names displayed for all to see as correct answers to his quiz questions are progressively registered.

Sometimes the girls half-heartedly try to join in, but for the most part, they do not.

By the end of the lesson, the class has been informed about the work of the eighteenth-century capacitor inventors, Ewald Georg von Kleist, and Pieter van Musschenbroek and Alessandro Volta's eighteenth-century invention of the electric battery. Also explained are the diode, electric amplifier and LED inventions of John Ambrose Fleming, Lee de Forest, Nick Holonyak Jr respectively and, how their work contributed to Konrad Zuse's 'Z1' 1930s electro-mechanical binary programmable computer. The final slide celebrates the work of Otis Frank Boykin and his invention of the electronic resistor.

As the bell sounds to end the class, the projected student 'score card' – and names on the whiteboard – doubly reveals that the only students who did not add bonus points to their tally were the same three students who were the first to leave the room. The three girls.

The observations that follow relate to two classes of Year 9 Electronics. In one class, there are 18 students, all students are male. In the other class, there are 20 students, 17 male and 3 female.

Both Year 9 Electronics (M, 15+; M, 25+) teachers told me that their elective was introduced to the school in 2006 and 'we've all been pretty much involved with the subject off and on since'. Interestingly, few mentions of the Year 9 Electronics subject, students, or classes were found in the Yearbook archives from 2006-2018. The only exception was found located in a 2015 Yearbook wherein two small photographs of one boy and one girl working on the same circuit board materials - using the same screwdriver sets that student were using in the classes I observed in 2018. This was explained to me by one Year 9 Electronics teacher (M, 15+), 'Doing Dick Smith project is nowhere near as sexy as playing with robots!'

Archived copies of the Year 9 Electronics course outline from 2006, 2009, 2014 and 2018 provided to me by one Year 9 Electronics teacher (M, 25+) revealed little had changed in the delivery of the Year 9 Electronics course in 12 years. Except for the new 'show-tell-quiz' mode of delivering lecture material using the overhead projector which both Year 9 Electronics Teachers started doing a 'few years ago' to 'better engage kids in theory' (M, 15+), the 2018 course continued with its initial requirement for students to complete ten individual practical activities outlined in Dick Smith (1979) *Funway into Electronics* Manual. Glancing through what one Year 9 Electronics teacher (M, 20+) called his 'Bible' (M,25+), I noted the *Funway* project book promised delivering 'hours of fun and excitement building 20 educational projects. Completely safe – ideal for all ages', along with its heavy emphasis on male figures occupied in in the illustrations accompanying each project (see Figure 8.1).

One Year 9 Electronics Teacher (M, 25+) also advised that since the subject first began, students had been required to individually work their way through each learning project, demonstrate its completion to the teacher who – once satisfied - would sign it off, allowing the student to move on to the next project. This work always involved individual students quietly completing individual projects, on their own. Practical materials were provided to students within individually named plastic containers (with lids), each housing parts replicating the original *Dick Smith* electronics kits as listed on the inside cover of the *Dick Smith* manual. These included: a project board, self-tapping

screws, washers, copper wire, hook-up wire, battery clips, speakers, resistors, and semi-conductors (diodes, LEDs and transistors) in addition to capacitors and electrolytics of varying voltages. Additionally, students were required to bring their BYOD notebook computers or iPads with them to each class. These were used for notetaking or looking up *YouTube* to help students individually solve problems, and sometimes - with teacher permission- for students to listen to music whilst silently completing their individual project work. Here the other Year 9 Electronics teacher told me, 'it's better for them to listen to music than distract each other' (M, 15+).

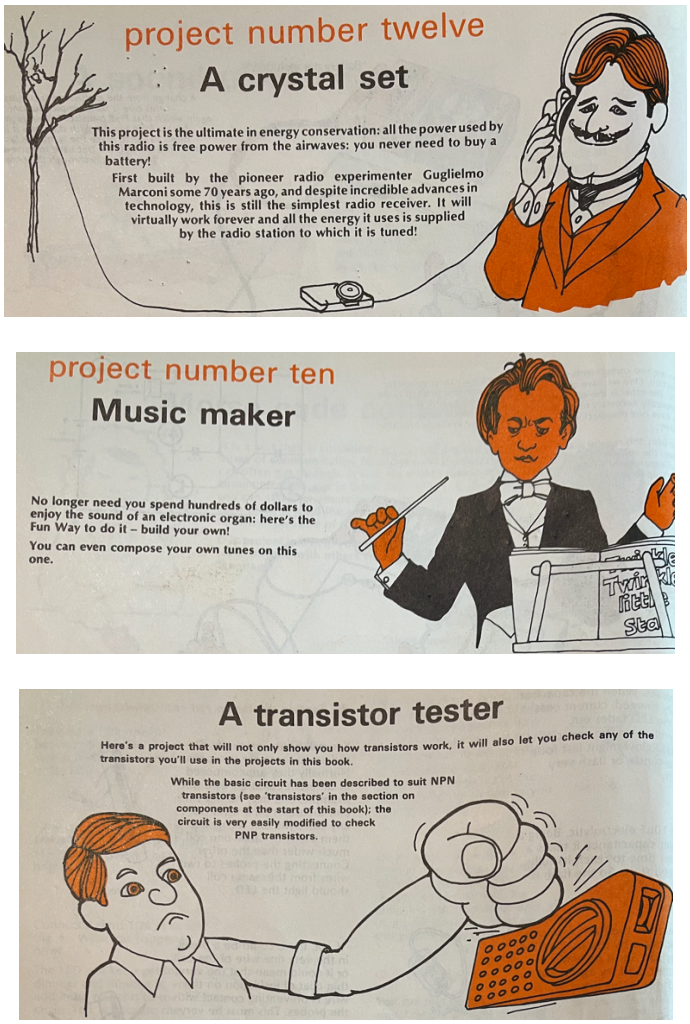

Figure 8. 1 Year 9 Electronics Project Illustrations from Dick Smith Funway Manual

A close examination of student course outlines and assessment schedules from 2006 through to 2018 revealed that the only thing that had changed in twelve years in the Year 9 Electronics subject in terms of assessment were the titles of assessments and modes of submission, wherein student work changed from paper assignments to digital submissions. Accordingly, over the course of more than decade, Year 9 Electronics students had been assessed according to four graded components, each

weighted 25%: first, the minimum completion of the first ten projects from the *Dick Smith Funway into Electronics* manual; second, an individual research assignment on the topic, 'History of Electronics'; third, two theory tests per semester; and last, a ninety-minute end of semester examination. Little if any opportunity was provided to students to engage in collaborative work, whole class discussions or projects which offered students' choice.

Of the 38 students completing the Year 9 Electronics elective, only three were girls. Noteworthy was the way the girls quietly got on with their work, headphones plugged in, during every lesson. None appeared keen to seek out the assistance of their teacher nor did the teacher choose to engage the girls when circulating the room, observing student progress. Here one of the Year 9 Electronics teachers (M, 25+) told me he had undertaken the school's 'Equal opportunity training course back in the day' which is why 'I don't stand over them because I don't want to make them feel uncomfortable.' He continued as we watched the girls working on their projects, 'girls are more patient with what they are doing - they are used to doing the more finicky stuff - so I don't want to hurry them or interrupt them' because 'in the end they produce higher quality work than the boys, just not as quick or as often. Girls just do things differently' (M, 25+). My six weeks of observing the girls in both Year 9 Electronics classes supported his assessment of the girl's work ethic. Lesson after lesson, week after week, without a word to the boys around them, the girls would quietly sit in the same spot, sort out their equipment, plug in their earphones, then go about the business of working through their individual project instructions.

Yet as I watched, I also noticed that two of the girls who sat next to each other seemed to have developed a system to support each other when cross checking their work against the instructions and circuit pictures in their project manuals more often and more closely than many of the boys. On these occasions - usually without speaking – one girl would check the work of the other's circuit boards for mistakes that may have missed. If either thought the circuit board was correct, a smile and a thumbs-up seemed to be the signal, if not, the error was pointed out with one finger on the circuit board and the other on the section of the instruction manual that had been misread or missed.

The girl sitting on her own - albeit in amongst a group of boys at the table nearest the door - used no such counsel. Rather, she habitually ran her finger down the manual's list of instructions and the circuit board picture at the back to make sure she was on track. Sometimes she would also take a photograph of the circuit drawing on her iPad to magnify it and make it easier to have two lots of

instructions open in front of her at the same time. In one lesson, she took her morse code LED project to the teacher to help her debug an issue she had tried to resolve on her own for more than ten minutes. Here the teacher first located the problem then proceeded to fix it without giving the girl the option to do this herself. This was not something he did with any of the boys. Significant here was the girl's quiet yet deliberate response. Upon returning to her seat, rather than moving onto the next project - which the Year 9 Electronics teacher advised her to do– the girl instead quickly typed up some notes on her iPad, took numerous close-up photos of the fixed project, then methodically began to disassemble her circuit board, taking care to put the various parts in particular areas on her benchtop – after which time she started over.

This time, she referred closely to the instruction manual, her typed notes, and photographs as she double checked each step. Once complete, for a second time, the girl stood up and took her project to the classroom teacher to check (M, 25+). Glancing at her work as the girl approached, the teacher appeared surprised she had chosen to redo her project saying to her, 'Oh, you didn't have to do this again. But that's okay. Let's see if it works this time' (M, 25+). Then, as the girl tapped out her Morse code for a second time, running her finger over the sequence indicated in the manual, I watched her hold her breath. Then, as the red LED lit up after she pressed the last code sequence, I saw her quietly do a fist-pump down by her side. Visibly relieved, she smiled as she watched the teacher tick off her name on his class project completion list before walking back to her seat.

8.5 Observations - Year 10 Robotics

15 November 2018

Even before the last chorus of Billy Joel's <u>We Didn't Start the Fire</u> has finished playing, the Year 10 Robotics students have entered the old Science lab room:

We didn't start the fire
No, we didn't light it, but we tried to fight it
Little Rock, Pasternak, Mickey Mantle, Kerouac
Sputnik, Chou En-Lai, "Bridge on the River Kwai"
Lebanon, Charles de Gaulle, California baseball
Starkweather, homicide, children of thalidomide

Seating themselves temporarily on heavy plastic chairs in three rows of low tables that span the width of the room in front of the teacher's raised bench, the students wait patiently as their teacher marks the roll.

Surrounding the students are windows covered with heavy grey blinds and long stretches of tall black vinyl wrap benchtops that sit on top of maroon drawers and cupboards that once held pipettes, test-tube racks, beakers, and conical flasks of various sizes. Now these cupboards are bare.

Every two metres or so, the benchtops are punctuated by disconnected gas taps and small but deep stainless-steel sinks. Viewed from the back, the room looks empty. Much too big for the furniture.

After marking the roll, the teacher reminds the class that they only have one lesson left to complete their Robot Extension projects and that their end-of-semester examination is fast approaching. He then instructs the class to use their time efficiently to work on their projects for their last lesson.

Immediately, small groups of boys jump up to claim - then secure - their favourite spot on the black benches lining the room. These are tagged with each group's well-thumbed programming instruction manual and one of the student's laptops that the group will use to run the dedicated EV3 programming software. As one boy from each group finds his group's Lego Mindstorms tub that has been stored on top of an unused trolley squeezed just inside the doorway of the old lab prep space, another quietly enters the adjacent classroom to retrieve his group's work-in-progress robot that the teacher has locked inside a tall, blue steel cupboard for safe-keeping.

As each boy returns to his group, others begin to stack two or three of the blue plastic chairs on top of one another, so they can sit at eye-level with the robot model that now sits on the benchtop in front of them.

Unmoved by the bevy of activity going on around them, the three girls in the class remain seated in the middle of the room for the entire lesson. For the next fifty minutes, none of the girls indicate the slightest interest in retrieving either their Robotics Kit or 'work in progress' model.

Instead, the girls settle in and chat quietly amongst themselves as they share one small laptop to switch back and forth between watching the latest Cardi-B music video and check out her fashions on The Iconic website.

The girls also take turns applying coral pink nail polish that one of the girls has brought with her. It is tucked inside her pencil case.

By the end of the lesson, all girls have every nail painted, and every nail is dry.

The observations that follow relate to one class of Year 10 Robotics. In this class there are 21 students, 18 male and 3 female. There is one male teacher who has been working at the school for more than 30 years (M, 30+).

Like the Year 9 Electronics course, the Year 10 Robotics elective had been run at Greenfield College for more than a decade. Advising that his subject had been popular since its very first year 'way back then', the Year 10 Robotics (M,30+) teacher advised that sometimes student demand required two

teachers to run up to four semester-length subjects per year. In 2018, there were two classes – one per semester – and the same teacher oversaw both. Appearing to support the Year 10 Robotics teacher's view about his subject were the many photographs featured on the 'Digital Technologies' pages in the 2006-2017 Yearbooks. Here the sole exception occurred in the 2018 where, for the very first time, the newly introduced Year 7 and Year 8 Maker technology subject featured instead of Year 10 Robotics. Noteworthy too is that of all the photographs found from 2006-2017 Yearbooks, only one girl (in 2013) was featured.

Although the content of the Year 10 Robotics course had not changed since 2006, and the class continued to use the same *LEGO Mindstorms* Robotics Kit (updated from Mindstorms NXT to EV3 in 2017], other more subtle shifts in how students were expected to engage with their robotics coursework had occurred. This is suggested by comparing the blurbs accompanying the photographs of Year 10 Robotics students in the 2007, 2013 and 2017 Greenfield College Yearbooks (see Table 8.3) whereby in 2007, the 'class worked together in groups' and 'together they learned' is transformed to individual achievements of 'I tested', 'I also learned', 'I relieved my childhood' and did 'extraordinary things myself' in the space of 10 years.

Pasted inside every student's workbook for Year 10 Robotics was the school's mandated 'Student Weekly Planner' – a document the Principal mandated all classroom teachers provide their classes at the beginning of each Term to ensure students received the benefit of a 'guaranteed, viable curriculum'. Pasted alongside was a 'Robotics Class Rules' list. Here the document's emphasis was on self-discipline, organisation, and respect for the equipment. Also mentioned was the expectation that students keep a 'Project Reflection Diary. When I asked the Year 10 Robotics teacher if he had a copy of this reflection diary for me to view, he picked up a student workbook and told me, 'no need, we stopped asking students to do that stuff a couple of years ago. Students weren't getting up to that part and complained when we took away marks for them not doing it. So, we just figured it was better to get them to do the tech stuff because that's what this subject's about'.

Robotics kits and other equipment were organised and distributed to students in the Year 10 Robotics class in a manner that mirrored the seamless process I witnessed in the Year 9 Electronics classes. However, because the Year 10 Robotics storage cupboard was in the room adjacent the Year 10 Robotics classroom space, at the start of each lesson, the teacher would always arrive early for class, unload student tubs from his cupboard and place them on the side bench prior to students arriving.

Yearbook	Author	Year 10 Robotics Greenfield College Yearbook Entries
2007	Male Teacher 25+ Years' experience at Greenfield College	'The students in this **class worked together in groups** to create robots that were equipped with light sensors, touch sensors and times turns to complete the team challenges that they are presented with. **Together they learned** how to use software on the computers to create programs for **their robots**. This allowed the robots to complete the tasks they were given, as well as move the robots in certain directions to get around corners or obstacles'.
2013	Male Student Year 10 Robotics	'Robotics is about building and programming robots using Lego *Mindstorm* NXT. **I tested** the robot's program with trial and error to logically solve a problem. In this class, **I also learned** to build and design my robots using a program **I made myself**. **I learned** to use the NXT programming environment and read values of sensors from the robot. While programming the robot **I learnt** how the program works in a logical order. **I relived my childhood playing with Lego and did extraordinary things myself'**.
2017	Male Teacher 25+ Years' experience at Greenfield College	Students **complete individual projects** which involve various elements of design, construction, programming, testing, software debugging, report writing and project presentation. From Semester 2,2017, students are using a new Robotics hardware, the LEGO Mindstorms EV3. This platform was launched in 2013 by LEGO in conjunction with MIT.

Table 8. 1 Shifting descriptions of Year 10 Robotics in Greenfield College Yearbooks

As each student entered the room, or after the class finished going through some theory, students would pick up their *LEGO MINDSTORMS* kits, a copy of the photocopied manual and each student's workbook then head back to their chosen group of tables or side bench to start or recommence work on their robotics projects. In this class, students used their own laptop – or sometimes shared one between two or three students – as the Technology support team had already installed the prerequisite software for each Year 10 student to undertake their programming tasks.

Just prior to the end of each lesson, without teacher prompting, students would begin to pack up. Again, like the Year 9 Electronics students next door, the Year 10 Robotics students appeared well-versed in returning photocopied workshop notes and workbooks to the plastic tubs on the side bench, returning their work-in-progress models back in the blue steel cupboard in the next-door room and stacking their Robotics kit boxes inside the cupboard or on the old trolley, located just inside the door of the old science laboratory preparation space.

Most assessment in the Year 10 Robotics class was project based whilst the remainder came from an end-of-semester examination. This meant for most of their course, students progressively completed a series of activities which included rudimentary software installation tasks, basic coding and programming activities and consistently adhering to class rules. Again, students were required to independently complete a mandated selection of 'Robot Educator' programs before then applying these to the building of their own Robotics projects which they could choose from *Robo-Lawnmower*, *Rubik Cube Solver*, *Fighting Aliens*, *Smash'n'grab*, *Crane Crusher* and *Gun Turrets*.

Like the Year 9s, prior to working on their individual projects, Year 10 Robotics students were required to follow step-by-step instructions to complete a suite of practice tasks set out in the 'Instruction Manual', then after the Year 10 Robotics teacher ticked each off as completed, Year 10 students would be given time to work independently to apply their growing repertoire of skills to their project robots. At the conclusion of each of the six weeks I observed of this class, the Year 10 Robotics teacher also consistently reminded his students of the need to prepare for their examination at the end of the semester.

When involved in double lessons (100 minutes instead of 50), the Year 10 Robotics students would be engaged for up to fifteen minutes at the start of each lesson with theory or practical work that the Year 10 Robotics teacher would deliver (and demonstrate) at the front of the room. Often this would involve the teacher plugging in his laptop into the Electronic display to assist student visibility. All students appeared engaged in this part of the lesson with many moving - without being prompted – to find a vantage point to better see what the teacher was doing. This sometimes meant those sitting in the back tables would drag their chairs to the front or middle of the room, which were then picked up and returned once the demonstration concluded.

Likewise, the Year 10 Robotics class engaged in 'Challenge Time' at the beginning of each class. Mirroring the engagement strategy used by the Year 9 Electronics teachers, 'Challenge Time' involved the teacher asking his students three explicit questions or posing three problems for students to solve that were directly linked to the new theory knowledge or practical work he had just demonstrated. Each question or problem progressed in its degree of difficulty and was scored from one to three points on the class 'scorecard' which was projected upon the whiteboard, along with student names.

After six weeks of observing this activity, I concluded that the boys in the class particularly enjoyed this task, as many jostled to attract the Year 10 Robotics teacher's attention so he would choose them

to deliver the answer, always calling out for their points to be added to the teachers list so their ranking lifted above their peers. As each question was resolved, the Year 10 Robotics teacher would call out the points he was allocating to student responses, as all participating students monitored their scores to ensure they were not robbed of their position on the teacher's public ranking.

Noteworthy here was that none of the three girls in the class demonstrated the slightest interest in this activity. Rather, as they sat together at the back of the room – surveying the grumbling boys in front of them – the girls looked on with amusement as they watched the boys partake in this activity. After one of the double lessons, the Year 10 Robotics teacher (M, 30+) explained:

> Students love these challenges. I use them to keep them on their toes, to wake them up after recess. But they love the competition. We have a new leader today, did you see? What's interesting to me is the boys at the very top aren't as good at actually building the robots as those in the middle.

Once 'The Challenge' was completed to the satisfaction of the Year 10 Robotics teacher, students worked on their preparation tasks, their core projects, or their extended projects. At this stage of the lesson, it soon became very apparent that the students across the class possessed very different skills sets and levels of confidence in completing these set tasks. For example, midway through Week 3 of my six-week observation period, some boys had almost finished the last adjustments to their first extension project whilst others were still yet to complete the first preparation tasks. Here I noticed too that that the Year 10 Robotics teacher keenly monitored the work ethic and progress of all students as he circulated the room to assist students or to keep them on track. Often, he would become engrossed helping students debug their programming or help with the physical building of their robots. At other times, the Year 10 Robotics teacher would stop by different table groups, ask students to demonstrate or show him their progress on their laptops or in their workbooks.

Of interest here was like the Year 9 Electronics teachers, the Year 10 Robotics teacher also kept his distance – and interactions - with the girls at arms-length, keeping himself nearby in case they needed assistance but equally not imposing himself on them like he did with some of the boys. This he explained to me after one class saying, 'when they are working well, I don't want to disturb them' (M, 30+). Further, the Year 10 Robotics teacher also disclosed that historically, few girls had enrolled in the Year 10 Robotics course, and that to the best of his recollection, 'at most up to five or six girls from the potential one hundred plus cohort of Year 10 students had the confidence to take up the challenge of doing Year 10 Robotics' (M, 30+). These low numbers – and therefore dominance of the subject by boys – was supported by the photographs appearing in the school's Yearbooks since 2006.

In every Year 10 Robotics class I observed, the three Year 10 girls who had elected to take up the Robotics elective sat together towards the back of the room. Even on the occasions when two of the girls were absent, the girl who attended would sit in the same position albeit by herself, and the boys would make no attempt to either invite her to work with them or sit with her.

Much like the Year 9 girls, each girl in the Year 10 Robotics class quietly and consistently engaged with the preparatory activities provided by the Year 10 Robotics teacher. For example, in the double lessons when the Year 10 Robotics teacher commenced going over theory or a practical aspect relevant to building the core robot tasks, two of the three girls would pick up their chairs and position themselves close to the front so they could clearly see and hear what the teacher was saying and doing. Thereafter, like the boys, the girls would return (with their chairs) to the back table, wherein unlike the boys, the girls would explain or tease out aspects of the new knowledge or practical work with her peers.

Further, although the girls demonstrated little interest in engaging in 'The Challenge' questions, the girls were active in seeking out advice from the Year 10 Robotics teacher, often taking their project up to him, notebook in hand, to ask questions or seek advice. Sometimes this involved going to speak to the teacher in front of the whole class and/or taking a seat at the front to attract his attention as he otherwise ran through one of the programs using the large projector screen at the front of the room for one of the boys. Of interest here was that whilst the Year 10 Robotics teacher was engaged in this work, it was only the girls who would sit quietly and take notes for future reference.

Here I noted after one class in the second last week of my observations that in each girl's workbook, the Year 10 Robotics teacher (M, 30+) signed off the girls' preparation tasks as 'complete' even though the girls had not finished all set tasks. Soon after, the Year 10 Robotics teacher told me 'I always make allowances for the coursework components for the girls to help them get through– so they don't need to complete as much as the boys' (M,30+). Of the tasks required, the Year 10 Robotics teacher also told me he learnt a 'few years back' it was better to 'let the girls complete their tasks together to get things done' as doing this creates a 'win-win situation for us all' (M, 30+). Such attitudes are reported by Louise Archer, Julie Moote, Becky Francis, Jennifer DeWitt and Lucy Yeomans's (2017) study of the 'conundrum of why so few girls persist' in the physical sciences and engineering'. Here, the authors argue that the issue is not 'gendered differences in science interest and attainment' (2017, p.89) but rather the masculine culture of science, underscored by the science

curriculum not ‘represent[ing] the interests and values of girls’ (p.90) and teachers ‘unwittingly reinforcing gender stereotypes’ by ‘communicating both explicit and implicit lower expectations of girls’ (p.90) that more aptly explains girls’ relative disinterest in STEM subjects and career pathways.

The ramifications of these deficit views of girls clearly manifested in the final lesson of my observations of the Year 10 Robotics class wherein I was not surprised to see that although each of the three girls attended their final lesson, none made the slightest effort to commence work on the extra robotics projects required of the boys. Rather, because the Year 10 Robotics teacher had signed off the girls’ incomplete work as ‘complete’, the girls instead sat together and chatted for the entire lesson. From my vantage point at the back of the room, sometimes I heard the girls mention their upcoming Year 10 Robotics exam, but for the most part, it barely rated a mention.

8.6 Summing up

Much like the Junior School Maker technology classes, there were several aspects related to teacher and student experiences with Maker technologies canvassed in Chapter 1 that were not confirmed by my observations of Year 9 Electronics and Year 10 Robotics Maker technology classes in Greenfield College. Again, no 'novelty effect' (Philip & Garcia, 2015) or observation of Maker technologies being a 'quick fix' (Philip & Garcia, 2015) to secure the academic and/or economic future of students attending Greenfield College was observed, as outlined in Chapter 2.

Similarly, the Middle School Maker technology teachers were also not observed lacking in confidence nor did they appear concerned to seek professional development opportunities to help them teach with Maker technologies. To the contrary, all possessed an easy confidence derived from all three classroom teachers teaching the same subjects, using the same coursework, in the same rooms, using the same equipment, for more than a decade. Indeed, so fixed did these three classroom teachers appear in delivering the same course content, using the same pedagogy, and same assessment metrics (as confirmed by my place document archive investigation in Chapter 5), that in some ways this team of Middle School Maker technology teachers appeared to have developed their own iteration of Tyack and Tobin’s (1994) *Grammar of Schooling* (see Chapter 2).

Furthermore, although the Classroom teachers were resigned to their material location (Monahan, 2001) and protective of their ‘hard-fought’ blocked teaching time per Semester (see Chapter 6), the Middle School Maker technology teachers did not have to contend with the haphazard

implementation (Philip & Garcia, 2016) suffered by Junior School teachers as the former had been using the same 'rebadged' (see Chapter 4) Maker technologies since 2006.

Further, unlike the Junior School Maker technology classes, the Year 9 and Year 10 Maker technology classes were consistently maintained by 'defined flow[s] of power, information, and authority' (Hodas, 1993) as outlined by early Educational Technology scholars in Chapter 2. Made manifest by a regimented structure of rules, expectations and behaviours designed to organise and control the work of long-established paradigms of teacher-centred pedagogies and curricular control (Peck et al., 2016) wherein students in both year levels were subjected to 'batch processing' (Tyack & Tobin, 1994), Hodas's (1993) 'rationalist model of the school-as-factory' and conception of classroom teachers as 'instructional delivery vehicles'. Each worked together to create an impression that when it came to girls' engagement with Maker technologies in the Middle School at Greenfield College, there appeared little prospect of historically established institutional or pedagogic conditions being disrupted inside Year 9 or Year 10 Maker technology classrooms to enable girls' engagement with Maker technologies.

This was consolidated by the curriculum resources used in Year 9 and Year 10 Maker technology classes as these depicted either an absence of females and/or the privileging of masculinity in curriculum resources as described by Bailey and Graves (2016), and Brugeilles and Crome (2009) in Chapter 3. Examples here include: the continued domination of 'powerful social groups' (Widdowsow, 2007) through the complete domination of only male figures and social roles being associated with electronics in the dated Year 9 Electronics Dick Smith *Funway* project book; the 'erasure of women's accomplishments' through both Year 9 Electronics teachers (M, 15+; M, 25) presenting only male inventors in the field of Electronics (Bailey & Graves, 2016); requiring all students to work on robotics projects in Year 10 wherein all but one is connected to destructive weapons of war; and allowing students' to use their 'free time' to play *CoolMathsGames* which further perpetuates through images, game activity placement of feminised icons beneath all others that 'valid knowledge' (Olson, 1989) is masculine.

Further problematising understandings of gender in the Year 9 and Year 10 Maker technology classes not expressed in the Junior School Maker technology classes was the explicit influence of historic understandings of gender. As outlined earlier and in Chapter 6, both the Year 9 Electronics (M, 25+) teacher and Year 10 Robotics (M, 30+) teacher reflected upon – and explained to me – how their

experiences of having their classrooms observed and receiving EO training as part of the school's Gender Monitoring Committee's work in the 1990s continued to shape and influence how either teacher treated girls in their classrooms. This was reflected by the way both teachers kept themselves at arms-length when circling the room and expecting girls to approach the teacher for support rather than offering impromptu assistance as per the boys. These classroom teacher behaviours affirm Connell's (2013) reflection of feminist scholarly concerns over the way 'gender monitoring' investigations in schools were consolidating social constructionist and biological essentialist views of gender as men/boys and women/girls. For Connell (2013) gender monitoring was therefore 'muting' otherwise consideration of the way social structures of schools – and the process of schooling – produce and, as is the case for this present study, reproduce gender inequalities by maintaining a view of girls as 'deficit' (Connell, 2013). As was noted in Chapter 3, such views of girls/women in relation to technology had long been challenged by the Feminist Technology Scholars (FTS) including Faulkner (2001) and Lageson (2015).

Moreover, clearly present in all Middle years Maker technology classrooms was a view that promoted boys' 'natural' technological expertise over deficit expectations for girls. This was exemplified by the way one Year 9 Electronics teacher (M, 25+) debugged a girl's Electronics project to complete it for her rather than advising the girl how to troubleshoot her own work, then telling her to move on with the next project (which the girl refused to do), whilst the Year 10 Robotics teacher (M, 30+) passed the three girls in his class without any completing all the work due to the teacher holding low expectations of the girls' abilities with technologies, despite them indicating otherwise.

Each of these examples is instructive as both surface not only how the deficit views of girls held by teachers were repeatedly positioning girls into powerless positions, but also opens the door to us challenging deterministic assessments of girls' engagement with Maker technologies that argue it is girls who 'naturalise' their own deficit classroom positionings. Helpful here is the work of Bryson and De Castell (1998) outlined in Chapter 3 which outlines similarly widespread beliefs amongst male school staff of girls/women's incapacity to cope with computing because 'left-brained' versus 'right-brained' people having different computing dispositions and boys/men being naturally more talented and more interested in computers and machines in general. Here, Bryson and De Castell's (1998) study goes on to discern that it is male staff holding biological essentialist deficit views of women and girls that lead them to using gender-differentiated pedagogies when teaching technological skills differently to boys and girls (see Chapter 3).

Finally, the very few optimistic moments observed in Middle School Maker technology classes related to girls' empowering themselves. Here the Year 9 girl who quietly fist-pumped down by her side when she finished her electronics project on her own terms defied her teacher's deficit expectations, whilst the Year 10 girls took advantage of their classroom teacher's deficit view of their abilities and early receipt of a pass despite only half-finishing their robotics projects. On this occasion, the girls also empowered themselves as they assumed the position of the observer – rather than the observed – as they happily conversed whilst watching the boys frantically working around them to finish their projects.

8.7 Looking forward

Thus far through its four Findings chapters, this thesis has outlined the presence of a broad range understandings about gender (biological essentialist, social constructionist, post-feminist, and neoliberal) being actively expressed materially, spatially, and socially inside the school gate of Greenfield College. In this thesis' two remaining chapters, the discussion will shift back to 'thinking with theory' to not only make sense of the story produced thus far, but also surface the power relations and therefore sites to locate feminist interventions to improve girls' engagement with Maker technologies – and by extension – STEM subjects and career pathways.

Chapter 9. Discussion

In contrast to much of the celebratory literature around Maker Education, this thesis has thus far detailed a rather messy story of girls' engagement with Maker technologies in one coeducational secondary school in Melbourne, Australia. Now, unlike much of the literature published in this emerging field (see Chapter 1), the remaining two chapters will attempt to make sense of this story by more thoroughly 'thinking with theory' (Mazzei & Jackson, 2012). It begins by situating the 'ethos' described by Hodas (1993) (see Chapter 2) of Greenfield College within its broader historic, economic, and political context. Thereafter, my analysis draws from a selection of feminist theories (see Chapter 3) to make visible hidden points of tension associated with gender that may account for girls' (non) engagement with Maker technologies in Greenfield College as described in the preceding four Findings chapters.

To explore this broad-brush contention in the detail it deserves, there are three sections in this chapter, each is framed using the present study's three research questions, i.e.

1. How did Maker technologies – and the idea of Making – find a place in the school?
2. How do the institutional and pedagogic conditions influence the use of Maker technologies in the school?
3. How did understandings of gender shape girls' engagement with Maker technologies in the school?

Crucially, this then provides a conceptual basis for the final consideration that this thesis had been leading toward – i.e., the questions of what maker education might tell us about the gendered nature of contemporary schooling and technology, and 'how might things be otherwise'? However, before we can consider any alternate forms of Maker Education in schools, the next three sections make sense of what was found in our empirical investigations.

9.1 The use and place Maker technologies in Greenfield College

As outlined in Chapter 1, most research focused on the use of Maker technologies in K-12 school settings is descriptive and can be categorised into four areas: (1) descriptions of how Maker technologies lift the engagement and motivation of students engaged in STEM activities; (2) reports of student Making activities; (3) outlines of emerging Maker technology pedagogies; and (4) descriptions of interventions using Maker technologies to positively influence equity-oriented STEM

education initiatives. As mentioned in this Chapter 1, much less visible are studies that place gender or feminist perspectives at the centre of their empirical investigations.

To set the scene for the following analyses, I too commence with description as I explore the 'what' and 'how' of Maker technologies in Greenfield College. Drawing from the classroom and broader site observations, document analyses and interviews with nineteen staff members from across the school's organisational structure outlined in my previous four Findings chapters, I begin by listing the types of Maker technologies found in the school. This is followed by brief descriptions of stakeholder understandings of the idea of 'Making', views on how Maker technologies entered the school and thoughts on the spaces where students engage with Maker technologies. Finally, stakeholder perceptions of barriers to student engagement with Maker technologies are provided. Each aspect is buttressed with insights drawn from scholarly literature.

Types of Maker technologies

Unlike schools using a more expansive array of crafting Maker technologies to achieve social justice orientated goals aligned with expanding Indigenous and/or girls' engagement with STEM (see Chapter 1), the Maker technologies used by students in Greenfield College fell only into the categories of Programming and Physical Computing. In Year 7 and Year 8, these included *Scratch*, *Arduino Sphero*, *Makey Makey* and *EdCreate* Robotics Kits. In Year 9, Maker technologies consisted of replications of electronics projects outlined in Dick Smith *Funway Electronic Kits*, and in Year 10, *Lego Mindstorm* Robotics Kits. For the purposes of this discussion, these have been differentiated as either 'new and attractive' or 'traditional but rebadged' as alluded to in Papavlasopoulou et al.'s (2017) literature review (see Chapter 1).

Almost all staff members indicated an awareness of the presence of 'traditional but rebadged' physical computing and programming Maker technologies, with all agreeing their purpose had always been to introduce STEM career pathways to Year 10 students. This knowledge is unsurprising given photographs of Year 9 Electronics students using Dick Smith *Funway into Electronics* kits and Year 10 Robotics students engaging with *Lego Mindstorms NXT* robotic kits featured every year in the school magazine over the period 2006 – 2017. Additionally, most teachers recalled instances where 'new and attractive' physical computing Maker technologies had been used in the school prior to the year in which this study was conducted. Described materially rather than known by name, examples included *Makey Makey* and *Arduino Sphero* kits - two of the most common physical computing Maker

technologies used by primary and middle school students (Schwartz et al., 2015). Also reported – albeit only by Year 7 and Year 8 Classroom teachers and Technology Support staff - were the 'new and attractive' *EdCreate* robotic kits and *SCRATCH*, the 'most-used' visual programming tool used in schools (Papavlasopoulou et al., 2017).

Maker technologies enter the school

Although most staff members reported working at Greenfield College school for more than twenty years, few could agree on how the 'new and attractive' Maker technologies entered the school. Given the school manages its large enrolments using a distributed leadership structure that provides relative autonomy to subject leaders, this lack of consensus is not in itself remarkable. Rather, it affirms Blikstein's (2018) view that many schools lack a detailed implementation plan and/or Cuban's (1986) belief that it is rare for teachers to participate in the top tier organisational decision-making process or plans for the said technology's implementation. Here, leaders and non-teaching staff were quick to point to individual teacher efforts when explaining how Maker technologies entered the school. These included key staff returning to school with 'showbags of goodies and a head full of fun ideas' after attending an educational technology expo or the single-minded passion of a former STEM teacher who trialled using Maker technologies in middle school science classes and lunchtime 'Maker Club' sessions to spark student interest in senior STEM subjects in 2016 – 2017 prior to leaving the school.

In contrast, Junior and Middle school classroom teachers directly involved with delivering the school's compliance with the mandated Victorian Digital Technologies Curriculum (see Chapter 5) were equally quick in providing a much more pragmatic response. Here the agreed view was that the 'new and attractive' *SCRATCH* Maker technology was brought into the school to support the new Year 7 and Year 8 Digital Technologies course because it was the 'cheapest and easiest' way to ensure the school met its compliance obligations. This too supports Blikstein's (2018) view that including Maker technologies in government curricula offers an immediate incentive for entire school systems to devise concrete schedules and programs to suit. Further, by using *SCRATCH* teachers unfamiliar with Maker technologies were able draw from familiar and embedded practices, thus offering them a degree of comfort in using a technology that has already been 'tamed' (Shepherd & Mullane, 2010)

Reasons for using Maker technologies in the school

More consistent amongst staff members across all levels of the school were perceptions about the potential benefits that Maker technologies could bring to students. Here most outlined a view aligning with Ryoo and Barton (2018) who suggest working with Maker technologies invites and engages students who may not normally consider themselves to be 'good at science' to learn STEM concepts and practices. Such notions are affirmed by Schad and Jones (2020) and Papavlasopoulou et al. (2017), both of whom found studies asserting that Maker technologies give students a greater reason for learning, involve students more deeply in their learning (Bennett & Monahan, 2013) and actively encourage students to engage in processes of 'getting stuck and unstuck' (Petrich, Wilkinson & Bevan, 2013).

All staff members also demonstrated little hesitation when connecting the so-called 'potential of student engagement' with Maker technologies to the skills associated with 'twenty-first century … catchphrase[s]' (Blikstein, 2018 p.422). Furthermore, all voiced a belief that students engaging with Maker technologies would 'value add' to their workforce prospects and hence fulfil the government's policy emphasis on assisting with Australia's 'global competitiveness' (Vossoughi & Bevan, 2014). Again, these perceptions are unsurprising given the prolific use of these 'buzzword' phrases in rationale statements published in formal curriculum documentation and other archived digital publications associated with government STEM policy initiatives to incentivize students to pick STEM subjects and career pathways (Blikstein, 2018) found in the school's digital archives. This includes documents related to the Victorian government's $128 million grant scheme made available to schools to purchase digital fabrication, programming, and physical computing Maker technologies in 2017, the year before the present study commenced.

Except for allocated classroom teachers, no staff had thought about – nor could identify - the ratio of male to female students in Year 9 and Year 10 Maker technology classes using the 'traditional now rebadged' Maker technologies prior to participating in this study. Yet, all interview staff very quickly asserted that Maker technologies would greatly benefit girls' engagement with STEM technology subject areas, particularly the notion that exposing Year 7 and Year 8 girls to Maker technologies would redress the attrition of girls away from STEM subjects. Here the existence of a deterministic understanding of the relationship between Maker technologies and girls' engagement with STEM was made clear when the Principal, the Assistant Principal and the Teacher-Leader of Staff Development optimistically described Maker technologies possessing the power to 'degender' STEM

subjects by removing threats that otherwise made girls feel 'too intimidated' to choose STEM technology subjects in school.

Helping us understand why the Principal and others held this view is Connell's (2009) argument that the notion of 'degendering' underwrites both Equal Opportunity and anti-discrimination reforms, including – as is relevant to this study - publications released by the Australian Government's Office of the Chief Scientist (OCS) entitled 'Busting Myths about Women in Stem' and the other, 'Women in Stem – A Story of Attrition'; both found in Greenfield College digital archives explored in Chapter 5. Yet, as outlined in Chapter 6, this process of 'degendering' or 'fixing' the 'problem of gender' in Australian schools specific to STEM has amounted to the pursuit of the liberal feminist affirmative action agenda and its associate 'gender monitoring' processes of 'gender washing and painting pink' (Heybach & Pickup, 2017) aspects of schools and the process of schooling. Thus not addressed, disrupted or answered are questions as to why or how girls are constructed as deficit in the first instance (Wajcman, 1991; Lageson, 2015) or why this 'problem' of deficit views of girls participation in STEM persists despite concerted efforts over the past two decades to attract girls to STEM by making STEM pathways more accessible, informing and encouraging more girls and women to 'make their way' into these areas through role models (Lageson, 2015; Heybach & Pickup, 2017) or by introducing programs into schools, such as the Maker Education initiative that is the focus of this thesis.

Makerspaces in the school

Few concerns were raised by the Principal or Assistant Principal about the 'Makerspaces' used by students when learning with Maker technologies. In contrast, as outlined in Chapter 6, classroom teachers quietly bemoaned but appeared resigned to using their allocated teaching spaces that were 'tucked away' in the 'oldest Science and tech rooms in the school'. Unrated too were the 'in-between' spaces I observed students using, including the floor space of classroom corridors and the floor in a Year 12 kitchenette. Contrarily, the relative lack of storage space and complete absence of display spaces to house student work - whether complete or in process – in any of these formal classroom spaces did not appear to be a point of tension amongst staff members. According to Blikstein (2018), this passive acceptance of non-dedicated spaces is not unusual in schools because it is 'rare to see top-down models developing these spaces' (Blikstein, 2018, p.432).

Yet this lack of attention to providing well-designed school Makerspaces and broad staff acceptance of students coping with 'inefficient' physical environments (Madariaga, 2015) runs counter to the emergent scholarship in this area. As outlined in Chapter 1, Maker Education scholars caution schools against simply equipping a school with Maker technologies in a room reminiscent of the computer lab era as this 'will do little to systematically leverage the affordances of the emerging Maker technologies to improve student learning' (Cohen, 2017, p.7). Moreover, Craddock (2015) highlights the need for schools to find creative ways to expose students to Makerspaces when trying to bring Maker-centred learning into schools; whilst Keune and Peppler (2019) recommend schools carefully consider the location of their 'Makerspaces' to foster pathway development of youth in STEM, particularly in terms of ensuring such Makerspaces are highly visible.

Institutional Structures

A clear disconnect existed between Principal and Assistant Principal perceptions of 'how' Maker technologies were being used in classrooms and the reality I observed. This was made manifest by the way the Principal and the Assistant Principal placed the responsibility for a lack of student engagement with Maker technologies squarely on the shoulders of deficient classroom teachers. No other institutional, operational, or pedagogic factors or conditions were considered. Indicating the presence of gendered power relations in an organisational hierarchy which are imbued with notions of 'dependence, autonomy and control over people' (Connell, 2005), both the Principal and Assistant Principal seamlessly listed a series of teacher deficits to explain the lack of girls' engagement with Maker technologies, including: 'risk averse' teachers, teachers lacking 'a vision of creativity', teachers lacking 'agility', teachers being unable to 'pivot', teachers lacking the 'hunger to do more' and teachers being unwilling to 'fit their Maker technologies teaching into the school's pedagogic instructional model'.

Such leadership views were not borne out in any of my classroom observations. Instead, I observed compliance in the classrooms of Year 9 and Year 10 classes where students engaged with 'traditional but rebadged' Maker technologies using the school's 'default pedagogy' (Thomson et al., 2012). Similarly, across the four observed Year 7 and Year 8 classes I witnessed teachers facilitating the 'new and attractive' *SCRATCH* Maker technologies in a manner that most certainly demonstrated a 'relaxed sense of control' (Sheridan et al., 2014) and seeming 'comfort with the unpredictability that may arise' (Eisenberg & Buechley, 2008, p.65) despite being very experienced teachers – and some nearing the end of their careers – teaching with Maker technologies for the very first time. Here too,

I observed teachers openly and collaboratively grappling with teaching the technical aspects of *SCRATCH* or the *EdCreate* robotic kits by working in partnership with students to 'find solutions to problems they could not answer' to the benefit of all.

Further indicating the disconnect between the Principal and classroom teachers were the more socially grounded suite of concerns raised by classroom teachers related to the school's organisational structures, policies, leadership priorities and pedagogical model as barriers to student engagement with Maker technologies. As outlined in the Findings chapters, particularly highlighted were concerns about short lessons, competing subject priorities, scheduling within an already crowded curricula, the school's accelerated SEAL program taking students away from elective options, the frequency of assessment and reporting, demands for teachers to frequently quantify student 'success' by numerical marks, and the mandating of a whole school standardised direct instruction 'default' pedagogical model (see below). Each of these concerns are confirmed in the emerging Maker technology literature as barriers to successful technology implementation; particularly barriers associated with the incompatibility of rigid structures of formal education curricula and assessment (Cohen et al. 2017), and studies that argue Maker technologies do not lend themselves to standardised assessment and reporting protocols (Halverson et al., 2014; Sheridan et al., 2015; Kafai, Fields & Searle, 2014).

Default Pedagogy

The most significant barrier to student engagement with Maker technologies identified by the Principal, Assistant Principal and Classroom teachers – albeit from opposite standpoints – was the school's standardised pedagogical instructional model. In Greenfield College, this one-size-fits-all standardised instructional model is a mandated requirement for all teachers to use across all year subjects and year levels. This standardised pedagogy model involves:

1. the teacher setting the learning goal for the students.
2. the teacher extracts prior knowledge from students.
3. the teacher presenting new information, facts, or skill processes, including the demonstration of how to solve predetermined problems.
4. students completing application activities to consolidate new knowledge, skills, and understandings.
5. students completing an 'exit ticket' - administered and collected by the teacher - to measure each student's performance.

Relevant to this study is the way the Principal blamed student lack of engagement with Maker technologies on teachers not using the school's 'default pedagogy'. Contrastingly, Classroom teachers were adamant in attributing the 'cultural imperatives in [the] school to lecture and test as the 'right' way to teach' (Martin & Stager, 2013, p.73) as the most significant impediment to student engagement.

To this point I have sketched a cursory picture of the 'what' and 'how' of the use of Maker technologies in Greenfield College. In doing so, I have purposefully described the school without giving due consideration to its broader context, and without using theory, as is the habit of most Maker technology research in this emergent field. However, by treating Greenfield College as an island, a place devoid of connections, a highly devolved, decentralised system in this manner I am acutely aware I have done little to explain or indeed begin to resolve the points of tension I have highlighted nor indeed the central concerns of this thesis. I address this deficit from this point forward.

9.2 The influence of school ethos on student engagement with Maker technologies

At this stage, most conventional explanations of Maker technology use in schools would conclude. Here, for example, we might finish by speculating on how the perceived 'barriers' to girls' use of Maker technologies might be addressed or overcome. We might consider alternate forms of implementation and use. However, for the remainder of this chapter, I now follow the small but growing body of work in educational technology research committed to moving beyond simple instrumentalist descriptions of 'does it work' and identifying 'enablers and blockers' in their studies of Maker technologies in schools. To achieve this end, Greenfield College is now treated as an opportunity, a point of entry to the exploration of the historic, economic, and political relations that have – over time – shaped the ethos of Greenfield College.

The problem of school ethos

Educational research focused on school effectiveness or school improvement (including studies on how to leverage digital technology to achieve such goals) often describe the 'ethos' of their case-study school as if it was a self-contained entity whose boundaries should be made explicit (Stake, 1995; Creswell, 2012). If I were to follow this conventional line of analysis, then I would note that the 2006 appointment of the current Principal was accompanied by a shift toward more regular (and explicit) neoliberal articulations of a school ethos that speaks of 'academic excellence', 'high

expectations', 'success' and 'individual achievement' (Forsey, 2006; Rottenberg, 2014). As we saw in Chapter 5, such pronouncements appeared in various digital and print publications, public displays, and other document artefacts. These could therefore be seen as an overt attempt by the Principal to foster pride and acceptance of a predetermined set of values, attitudes, beliefs and conduct that had no meaning beyond the school gate or - as is more likely the case - an effort by the Principal to adhere to the neoliberal market logic enunciated by State education policy reforms which required her compete with other schools in the area, touting Greenfield College's academic results as a 'distinct product' to create a market niche for the school (Forsey, 2005, 2006; Lombardo & Meier, 2006;).

Nevertheless, given the theoretical underpinnings of this thesis, it makes sense to develop a more contextualised account of the school's 'ethos' (Hodas, 1993) – looking beyond these official proclamations and attempts to recast the school. Instead, given 'the physical environment of the locality [of a school], its reputation and the reputation of the school within it, operat[e] as mutually reinforcing signifiers' (Hollingworth & Archer, 2010, p.590), to develop a more nuanced understanding of the school's ethos the present study will now 'slice the school into different planes' (Nespor, 2002, p.xii). Accordingly, this allows us to revisit the 'from below', 'unofficial' and 'insider' descriptions reported in Chapters 5, 6, 7 and 8 as 'active agents' (McGregor, 2003) to surface some of the contextual and mediated factors which dynamically shaped the seemingly static iteration of ethos in Greenfield College. In this sense, I propose that several relational entanglements have each brought their own sets of values which have – over time - materially and socially shaped the ethos of Greenfield College.

Education policy - the cornerstone of school ethos

First, the preceding chapters highlighted government education policy as a cornerstone that connects most external influences on the ethos of Greenfield College. This began in the 1980s with the State's wide-reaching shift toward decentralised school governance in the form of self-managed schools. Older teachers with a thirty-year plus history of working at Greenfield College recalled the demoralising impact that the forced closure of 370 schools in Victoria had on the school in the mid 1980s; particularly the uncertainty and insecurity many colleagues felt due to the substantive job cuts they witnessed at this time.

In the next decade, radical changes to Victorian education policy in the form of the *Schools of the Future* reform package were introduced, premised on a need for the 'Victorian education system to

play its part if Australia was to be economically competitive on a global scale' (Hayward, 1993). Here, the use of 'future' in the policy's title (the first of many times this was to appear in subsequent government policy documents) implicitly signalled the government's intention to move beyond 'old world' values and histories of schooling – not least what were perceived by many educators as notable inefficiencies, decision making hierarchies, burdensome rules, and regulations. For Greenfield College, the *Schools of the Future* initiative prompted a concerted effort throughout the school community to move on from an historical imaginary of the school as 'a tough place with poor attendance, low performance, and almost zero expectations about doing better'. As described in Chapter 5, the legacy of these years still resonates through the signs 'It's not OK to stay away – 90% attendance' still located in every classroom and every corridor.

The influence of early government policy interventions took on several forms reflected in the school's ethos as I encountered it during my fieldwork. All of these could be said to have shaped the way Maker technologies had been introduced into the school. For example, the school was making notable efforts to appear innovative, entrepreneurial and business-facing – all in line with the *Schools of the Future* neoliberal emphasis on market forces of competition, choice, and individualism in Greenfield College's ethos. New programs were promoted such as 'Pathways Beyond School' to bolster support from local industry and businesses, albeit with little initial success. In doing so, the school presented itself to parents, students, and its local community – or prospective 'clients' and 'customers' - as a bound system (Forsey, 2006). In Hayward's (1993) terms, this involved a deliberate reframing of the school as an 'island' organisation who will actively develop its own school charter – and ethos – in a manner befitting of the attributes of 'good schools' outlined by the *Schools of the Future* policy framework.

My findings also point to the influence of the subsequent 2003 *Blueprint for Government Schools: Future Directions for Education* (State of Victoria, 2003) which consolidated this policy rhetoric of schools leaning into the 'future'. Heeding *Blueprint* calls for schools to 'compete against each other for mainstream enrolments [as they] focused on high achievement data' by using 'new approaches to improve student learning', Greenfield College introduced a SEAL (Select Entry for Accelerated Learning) program in 2005 to facilitate high-ability students using the buzzword neoliberal accolades of 'higher order thinking skills, independent learning and research … creative thinking, research, and problem solving skills' to help them 'successfully move through normal 7-10 curriculum at a faster rate [and] complete their six years of secondary school in five.' As described in Chapter 5, the school's

SEAL program had been very successful, and was a prominent focus of how the school promoted itself to prospective parents. Tellingly, these students - all girls - were also the most engaged with Maker technologies in the Year 8 classes I observed.

Strategic External Partnerships

From these foundations, we also saw in the previous Findings chapters how various other interconnections 'knotted' within Greenfield College. Explored in Chapter 5, these included: corporate sector businesses keen to participate in the 'business of learning', corporate not-for-profit social enterprises focused on helping students 'lift their potential beyond their postcode', tertiary education research partners, professional leadership training bodies, key advisers from the Department, local businesses and various individuals – including university sector pedagogues, former Principals, retired teachers - employed as external consultants to build the 'professional capital' of staff in data analysis, assessment, content knowledge or pedagogics skills. Of interest here too is that rather than forming the professional relations with other schools as per the *Leading Schools* descriptor contained within the *Blueprint* policy, Greenfield College instead turned inward as it focused instead on improving (and consolidating) the 'connections' students, teacher and parents 'felt' about 'their' school. Again, all these characteristics could be seen reflected in the nature and form of how Maker technology found its way into the school.

Default Pedagogy

Finally, to galvanise the school's standing in the external community as an established model of 'high performance' with a celebrated school ethos of 'excellence', 'individual academic achievement', 'success' and 'high expectations' for all, and especially for girls, the school notably made efforts to standardise the pedagogy used in the school to deliver all teaching and learning programs, across all year levels. This was facilitated by bringing in an external consultant, with a 'global reputation' for working with schools across the world on long-term projects aimed at boosting student learning via standardising teaching practices and instructing each new intake of staff on how to operationalise the school's localised version of her unidirectional teacher-centred direct instruction pedagogical model (see Chapter 5, 6 and 7).

The Principal was resolute and determined to reap the rewards of this substantive investment which mandated all staff – without exception - deliver on the school's promise of 'high expectations' and 'high performance' and 'success' by providing all students access to a 'guaranteed curriculum' using

this lock-step teacher-directed pedagogy from start to finish. Labelled a 'default pedagogy' by Thomson et al. (2012), this standardised model of pedagogy defines excellence in terms of progress against a limited set of measurable indicators. Further, its emphasis on the individual erodes the sociality of a school by making the pedagogical processes (and the empirical data generated from them) more important than people (Thomson et al., 2012, p.15). Thus, it was through the mandated use of this default pedagogy that the Principal also ensured that all members of the school community became complicit in demonising the 'frequent variations in outcomes between classes' as per *Blueprint* requirements whilst simultaneously consolidating the school's 'high performance' brand.

Thus, as we now return to the question of student engagement with Maker technologies posed in the previous section, we have a fuller appreciation that the tension-points or 'knots' present in the differing perceptions of barriers to student use of Maker technologies cannot be explained separately from the school's evolving ethos. Indeed, all the factors just described – from the notion of excellent teaching through to a rigorous defined standard pedagogy – all proved to be key influences on how Maker technologies were received into the school.

Crucially, these influences did not originate within the school itself. Thus, it is better to view Greenfield College as a microcosm of the wider world of neoliberal education reforms, both permeated by and containing the external context in which the school is situated wherein neoliberal feminism exhorts 'gender equality' to mean individual economic empowerment (Colley & White, 2019). This is made manifest each time the school publicly proclaims student achievements of 'academic excellence' and is publicly exhorted as an exemplar of a 'high performance' school 'despite the destiny' prescribed by the school's postcode. In such ritualised moments - which commenced as early as 2007 - the school reveals that its tall, steel spiked picket fence and heavy steel gates are no match for the historic, socio-economic, and neoliberal political forces that have irrevocably shaped the forces of 'hyper-individualism' collective (Banet-Weiser et al., 2020) that infuse and sustain the Greenfield College ethos.

9.3 The influence of institutional and pedagogical conditions on student engagement

Viewed through the lens of social theory (see Chapter 2), the increased presence of strategic partners within a school substantively contributes to the relational ebb and flow of multiple factors, relationships, individual, organizational, pedagogical, and technological variables. In particular, the

increased presence of strategic partners in Greenfield College could be said to increase the centralised authority of leadership, particularly regarding social control. This point is affirmed by Monahan (2005) who argues that when schools open their gates to accommodate global expectations and industry needs, schools exercise a 'double movement'. First, is a tendency to scale back of the school's social and civic functions wherein an individual's interest in achieving economic and professional success overrides concerns for or about the 'structural or economic undergirding' of continued gender inequalities suffered by the collective (Banet-Weiser et al., 2020); and second, is an increased centralisation of the school's internal locus of control which, in turn, marginalises teachers, parents and students (Cuban, 1986, Peck et al., 2016). Understanding these shifts in Greenfield College is a key part of making sense of students' engagement with Maker technologies.

Accordingly, I now engage with spatial theory outlined in the earlier theoretical chapters to explore the social, cultural, and political attributes of Greenfield College's 'rationalist model of school-as-factory' (Hodas, 1993). This helps me surface the 'powerful institutional forces [that] prohibit the successful implementation of new technologies in schools' (Cuban, 1986).

Ethos and Space

To understand how ethos influences the engagement of students with Maker technologies, I conceive of spaces inside Greenfield College not simply as a geographical area within which social action takes place, but rather as a localised coming-together of the physical environment and social relations and practices (see Chapter 3). Seen through the lens of spatiality (Keith & Pile, 1993), the idea of the school being able to establish a 'Makerspace' is not a simple matter of integrating technology into a classroom. Instead, as outlined in the Findings chapters have documented, Greenfield College's 'Makerspaces' need to be seen as places where people, practices and places relationally entangle (Justice, 2016) with the school's ethos in an 'active symbiosis of becoming' (Acton, 2017).

This means I reject analyses of school 'Makerspaces' that consider them somehow separate from social practices and, in and of themselves, dialogically enabling actions and exchanges that give 'power' to 'Making'. Instead, applying spatial theory to this thesis's account of Makerspaces in Greenfield College enables me to make better sense of the tensions occurring at the junctures of spatial-social relationships, particularly those places where a school's ethos infuses expressions and enactments of centralised authority which, in turn, are ritually 'socially produced and consumed' (Hubbard, Kitchen & Valentine, 2004). It therefore follows that my examination of the relational

materiality of spaces and social practices associated with Maker technologies begins from a position where school ethos is considered a fluid and dynamically relational concept that is 'in-movement' (McGregor, 2004; Massey, 2005), porous and permeable in its sociomaterial relations, not static.

Sociomaterial perspectives of the school's Makerspaces

Whilst many schools define regions of space and permissible forms of spatial behaviour in terms of their physical separation from other spaces (including the artefacts and people contained therein) the boundaries around these spaces have long been understood to be porous (McGregor, 2004; Massey, 2005). From this perspective, the dynamic influence of ethos and how it flows through and within Greenfield College can first be located through the various ways the school endeavoured to spatially - and materially - demarcate itself from the day-to-day action of its neighbourhood (see Chapter 5).

Viewed through a sociomaterial lens, my Findings chapters detail various attempts by the Principal to infuse a sense of authority and discipline into physical spaces. Examples include the repetitive use of clean sharp lines, perfect alignment, and the pristine maintenance of the school's external landscape. Borders here too seem purposefully created to separate the school from its local neighbourhood, a deliberate effort to cement an impression of the school as a closed system, a positive presence amidst its low socio-economic neighbourhood. A place where subscription to the school's ethos of 'excellence', 'high performance', 'high expectations' and 'success' is read not only through the landscape, but also delivers on the promise of certainty, security, and prosperity (see Chapter 5).

Similar efforts to exercise social control using physical space (Monahan, 2005) punctuate the school's internal areas. The clearly defined physical borders described in Chapter 6 – both inside and outside - functions to actively marshal students into litter-free locales reserved for civilised student recreation whilst other zones of permitted use are clearly distinguished by crisp painted lines or landscaping. Inside hallways and classrooms, the influence of the school's ethos creates spatial disciplinary patterns. Few interruptions trespass the uniform military colour palette via either colour or displays. Instead, only bright yellow hazard lines run up the centre of stairwells or around walkway posts or split concrete footpaths into controlled zones of movement between buildings; each working to corral the movement of students between classrooms, lockers, and other areas in the school.

Thus, it is not surprising to see these logics repeated in the spatial arrangement of the school's 'Makerspaces.' Like the rest of the school, these were marked by laminated signs on every door and every internal corridor window exhorting high levels of attendance and the expectation of precision in the wearing of student uniforms. Located in precisely the same position inside every classroom, signs high above each whiteboard proclaimed the school ethos of 'high expectations', 'academic excellence' and 'high performance' and 'success' just adjacent to – and therefore making an implicit connection to - a larger poster declaring the 'Default Pedagogy' acronym familiar to every teacher and student in the school.

These efforts to control spatial relations within general-purpose classrooms – and the Makerspaces located on the outskirts of the school – are indelibly linked to the Principal's edict requiring teachers to uniformly deliver the school's 'Default Pedagogy'. Here the notion that space and social practice exist together, as mutually constitutive, or intertwined, resonates in the initial training all new teachers to Greenfield College receive at the time of their orientation. At this time, new staff are trained to adhere to these norms and expectations, particularly the school's commitment to using pre-determined and unshifting spatial configurations in all classrooms. This is to complement each teacher's exercise of complete social control by intermittently circulating and surveying students whilst delivering the tightly segmented components of the school's 'default pedagogy'. Hence, all staff (and students) are aware – again through signage in a precise location replicated in all classrooms – that the prescribed double 'E-shape' configuration of desks remains in place. This consolidates regimented patterns of disciplinary compliance across the school that influence teacher and student behaviour and relationships, whilst also ensuring only a limited number of permitted learning activities are experienced by students.

The school's 'Makerspaces' mirror the spatial disciplinary patterns established in these general-purpose classrooms. Thus, in contrast to the fluid and free connotations of Maker technology exhorted in Chapter 1, Greenfield College's 'Makerspaces' conform to centralised efforts to socially control the spatial relations that occur within all other classrooms (Smith et al., 2016). For example, lining the periphery of the Year 7 and Year 8 computer laboratory where students engage with the 'new and exciting' *SCRATCH* Maker technologies, desktop computers are positioned in ways that enable teacher surveillance of how they are being used in the same way as their colleagues who used the computer lab almost two decades ago. In the centre of the room are rows of tables facing the front of the room that mirror the positionings, objects and expectations found in all other general-

purpose classrooms. Likewise, in the disused science labs timetabled to Year 9 and Year 10 students engaging with 'traditional but rebadged' Maker technologies, the assortment of benches and tables also point students' attention to the front of the room (see Chapter 7). Moreover, students engaging with Maker technologies within these repurposed specialist rooms also find themselves working in spatial relation with the lingering artefacts and architecture, practices, attitudes, and decisions associated with the school in the 1980s.

The Spatial shaping of student experiences

Seeing the school's 'Makerspaces' in terms of their 'spatial hybridity' (Burnett, 2011) highlights that student seated at any desk within any classrooms will not necessarily 'see' the particular significance of that space in relation to its specific location nor in the same way as others located within this same space. Rather, a teacher or student's 'view' of this space materially filled with artefacts, processes, practices, and protocols enacted therein are better understood as being interactions with peers or teachers; through students drawing upon practices or experiences or relationships to people; processes or things developed in other places. This means that within any one experience of the school's Makerspace, students and teachers may feel disconnected or bring and overlay different kinds of experiences which, over time, may be consolidated by other experiences, in other times and places (Thomson & Hall, 2017; Justice, 2016). It is for this reason that Zhao and Frank (2003) propose researchers 'attune themselves to the ebb and flow of multiple factors' when attempting to focus on the material, discursive and symbolic contexts of schools.

My observations of students engaging with unfamiliar practices associated with Maker technologies (albeit using the very familiar mechanisms of assessments and tests) demonstrates how relational spaces filled with past discomforts (i.e., doing tests) (Monahan, 2005; Connell, 2013) can socially produce a 'present' that denies 'a smooth and automatic process' that is 'without resistance or constraint, onto the landscape' (Soja, 1985, p.97). Here Greenfield College's neoliberal ethos is lived through anxiety-riddled (and frustrated) Year 8 students sacrificing marks (and a high grade) on their test papers by refusing the instruction to not erase working out notes on their coding sheets. Elsewhere aspirational 'high performing' Year 7 students visibly shed tears on their test papers when confronted with not knowing how to follow this same instruction or how to reconcile the consequence of losing marks due to running out of time. I also saw Year 10 girls' happily accepting their classroom teacher's decision for them to forgo completing all tasks in their summative

assessment, thereby fulfilling his low expectations whilst also providing the girls' their required passing grade which they received without complaint.

Each of these examples highlights that no matter the efforts of the school to steer students into its guarantee of 'sameness' (Shrewsbury, 1997), student learning experiences with Maker technologies are individualised, patterned and dynamically shaped by individual student and teacher 'articulations' between different domains, different values, priorities, and relationships (Nespor, 1997). Particularly instructive here is the exuberance observed amongst Year 8 SEAL girls when independently co-constructing their *Edison* 3D-Printer model – mostly on the floor of the kitchenette used by Year 12 students across the corridor from the computer lab where the Year 8 Coding class was held. In this example, even if only for a moment, new kinds of sociomaterial relational practices emerged that disrupted both social spaces and structures infused with the dominant discourses of the school.

Temporal shaping of space

Another facet of applying a spatial perspective in this study is the idea that space is inextricably linked to time in terms of how people understand, and act within, and on, their environment (Leander & Sheehy, 2004). This is particularly the case in schools, wherein both time and space are highly regulated yet thoroughly entangled with other ethos infused rhythms and constraints, throughout the school day, week, term, and year. This relates to Giddens's (1985) point that whilst space is important in understanding relations between schools, broader societal structures, and individuals' experiences, it is also important to pay close attention to how the location in time and space gives power and authority to school activities, subjects, and groups.

Seen along these lines, several spatial constraints were found to pattern the availability of Maker technology subjects in Greenfield College. For example, Year 7 and Year 8 Maker technology electives were blocked with the 'non-core' Art, Food Technology and Textile subjects in the school's timetable. Afforded by the redistribution of lessons from a cancelled Design & Technology elective subject that 'made room for' the Year 7 and Year 8 Coding subjects, Maker technology electives were available to students for only a small number of lessons per week over a 10-week term. Consequently, whilst the school fulfilled its Victorian Curriculum compliance obligation to deliver the 'Digital Technologies' curriculum – or part thereof - it also set in place the reality that a Year 7 student could only ever hope

to undertake a Maker technology subject once in a single 10-week term over any given two-year period.

Elsewhere, I have explored how SEAL students were also spatially constrained by the timetable as their accelerated learning program prioritised 'core' subjects over providing students with further opportunities to engage with Maker technology subjects after their Year 7 or Year 8 electives were complete. This was because the key attribute promoted to parents of students engaged in the SEAL's 'high performance' program was that the SEAL program would 'move students through normal 7-10 curriculum at a faster rate [to] complete their six years of secondary school in five.' To facilitate this acceleration, subject choices were narrowed at the expense of elective subjects at Year 9 or Year 10, including the Maker technology elective options.

Similarly illustrated is how spatial arrangements lend power and authority to school activities is how time is strictly governed – and distributed - in the school's 'default pedagogy' through the requisite use of strictly timed teaching segments. Again, in contrast to the fluid and flexible spirit of 'Making' outlined in Chapter 1, these rigid regulations materially and spatially curtailed what could be done with Maker technologies during any given lesson, on any given school day, week, or term.

9.4 The influence of 'gender' on student use of Maker technologies

To this point we have explored how students' engagement with Maker technologies was shaped by the school's institutional and pedagogical conditions, and its general ethos. This section now examines these influences in terms of gender, and the notably gendered nature of Maker Education throughout Greenfield College. This is first done by considering the enactment (and entanglement) of official gender equity policies within the school. Thereafter, I explore how dominant tacit understandings of gender shaped and influenced the structures, pedagogic practices and, ultimately, girls' engagement with Maker technologies. In short, this section aims to add gender to my thick description of girls' engagement with Maker technologies at Greenfield College.

Greenfield College and 'gender equality' policy

In one sense, Greenfield College was home to a long history of gender-related policies intended to support girls' equal engagement with aspects of schooling, such as engaging with Maker technologies. As outlined in Chapter 3, efforts to change girls' experiences of schooling and the curriculum from the 1980s have been strongly influenced by binary, biological essentialist categorical

understandings of gender that undergird the affirmative action politics of both liberal feminism and more contemporary iterations of neoliberal feminism.

Gender as a binary category

Socially constructed categorical understandings of gender equity associated with liberal feminism (Connell, 2013) and neoliberal feminism (Rottenberg, 2014) (see Chapter 3) and their declared dependency on comparing girls against boys (and vice-versa) (Ringrose, 2013) were evident on multiple occasions in Greenfield College. Fleshing out the images and blurbs discovered in Yearbooks, newsletters and other internal correspondences were the interview insights offered by most all long-serving members of staff as they reflected upon the story of Greenfield College's Equal Opportunity (EO) journey. This included Department funding for a 'special' Equal Opportunity Officer role and program, the training and promotion of more 'women leaders' and the instigation of a series of student-parent information evenings throughout the year which profiled 'successful' female guest speakers from a variety of industries. Also recalled was the formation of a student Equal Opportunity (EO) committee and teacher-student 'working parties' who ran whole-day, whole-school workshops to 'educate boys' about how to change their behaviours and attitudes toward gender violence and gender equity.

Furthermore, teachers in the school (both male and female) recounted regular 'EO Learning walks' around the school, and classroom observations by an EO panel of teachers who visited classes to count (using pencils and clipboards) the number of times girls spoke versus boys, how girls moved in classrooms relative to boys, and how boys interacted with girls and vice-versa. Curriculum materials and textbooks were scrutinised, the language of assessment tasks vetted, and the names of subject offerings modified to ensure 'harder subjects' were 'attractive' and 'less intimidating' to girls. The Principal, and one of the Teacher-Leaders, who were also lead members of this EO panel in the 1990s – proudly recalled the success of Equal Opportunity professional learning sessions for teachers, including those focused on raising teacher awareness of 'gendered practices', the language used in classrooms, and how either could be detrimental to girls' confidence. Here, two long-serving Middle School Maker technologies (M, 25+; M, 30+) also recalled attending professional learning sessions focused on how to 'consider the presence of girls' and the requirement to explicitly reference to how girl would be attended to in the class in lessons plans. This was to ensure the 'male teaching style' did not perpetuate the privileging of 'masculine' models of learning (see Chapter 8).

Particularly revealing here too is the way staff members explained the ending of this purposeful, driven and committed period of Equal Opportunity interventions. Explanations such as it 'just slipped away' or 'faded away' or 'just disappeared' or 'got lost in the mix of the school day' were common. So too were suggestions– including from the Principal – that there was 'nothing more to see' because 'the job was done'. As our investigations of students' engagements with Maker technologies midway through 2018 illustrate, this was certainly not the case.

Postfeminist accounts of 'Successful' Girls

As outlined in Chapter 3, the 1990s (and continued) educational panic over failing boys contributed to a new neoliberal 'postfeminist' discourse about 'successful girls'. Here girls' individual educational performances were celebrated and used as evidence of broad educational policies enabling 'girl power, possibility and choice' (Ringrose, 2007; 2013). Complicit in promoting the 'successful girls' liberal feminist binary understandings of gender buried deep within this 'successful girls' thinking, Greenfield College joined the broader community chorus of applauding 'high performance' academic achievements of girls relative to boys each time NAPLAN or end of year VCE exam results were released. Internally this was evidenced in staff presentations, strategic planning documents, annual reports to the school community, curriculum planning discussion minutes and gender differentiated honour boards set up in the general office areas.

Outward bound communications to the school's broader community similarly affirmed that inside the school gate, the gender equity 'job was done.' This was made manifest through parent newsletters, prospectus documents, website pages and real-estate advertising boards placed along the school's fence line which visually ranked happy photographs of girls' academic achievements over and above the lesser number of boys. As explained in Chapter 3, these public presentations of girls' excellence exhorted not only the individual performance of girls' success over boys but also further cemented binary essentialist categorisations of gender associated with liberal feminism affirmative action and the ethos of Greenfield College; albeit in 2018 from the vantage point of oversized corporate sponsored billboards locked by key and chain to the school's tall, spiked picket fence.

The Greenfield College gender regime

My aim in applying Raewyn Connell's (2009, 2002) gender regime at this point is to make sense of the 'thisness' (Thomson, 2000) of the gender regime that prevailed within Greenfield College. As mentioned at the beginning of this chapter, I am unconcerned with resolving the tensions or

explaining the inconsistencies I surfaced. Rather, this section instead seeks to surface – then reflect on – the influence of the dynamic nature of the school's gender regime on girls' engagement with Maker technologies in the school. Hence, the last sense-making stage undertaken in this chapter draws from Connell's four relational gender 'tools for thinking through' (2009, p.85) the analysis of complex relationships that exist between gender and social structures in organisational settings. Here Connell's (2009) relational approach raises a series of points that chime with my accounts of girls' engagement with Maker technologies at Greenfield College.

First is the argument that the gendered values underpinning external national 'gender equality' education reform policies - such as *Victoria's Schools of the Future* and the *Blueprint*– are implicated in the shaping of a school's ethos and, in turn, the gender regime operating within a school. Here, Connell (2013, 2009) refers to neoliberal values influencing the ethos of schools – such as Greenfield College - wherein 'the school acts as a firm competing with all others for students, marks and money, in markets where parents are consumers expected to exercise 'choice' between different schools. In this regard, Greenfield College also confirms Connell's (2009) further assertion that localised iterations of an individual school's gender regime may reproduce societal patterns of gender relations existing within the broader external context.

Power relations

As outlined in Chapter 3, Connell's opening gender dimension – power relations - threads together ideas of 'dependence, autonomy and control over people' (Connell 2010, p.172). Here gender is expressed through 'the way control, authority, and force are exercised on gender lines, including organisational hierarchy, legal power, collective and individual violence' (Connell 2005, p.7). In Greenfield College, broader societal concerns, and a determination to exert control over the external 'moral panic' (Epstein et al. 1998; Francis & Skelton, 2005) in boys' education influenced the Principal of Greenfield College as she restructured and centralised the school's 'middle tier' of leadership to provide closer scrutiny, control, and discipline of all students across the school.

Focused on redressing the 'boys' crises' in education whilst also 'keeping girls safe' saw the Greenfield College allocating a small number of students to a single 'Learning Leader' who was charged with personally managing each individual student's discipline, academic achievement and wellbeing (in this order). From this point, parent contact with teachers was severed as the 'Learning Leader'

instead became the mediator – and conduit – controlling all parent-teacher-student communications, and relationships.

Also, in response to the 'boys' crises', the Principal introduced a highly structured Literacy program that separated boys and girls into same-sex classes. At the same time, the Literacy Leader role was elevated to Teacher-Leader status to enable the incumbent to 'take charge' of – and turn around - the significant deficits in boys' literacy levels. Further supporting these measures was the introduction of the school's 'default pedagogy' (as already discussed), and its accompanying regular pattern of 'assessment dense' standardised 'common assessment tasks' across the school. According to some staff members, the Principal's efforts to 'turn around' boys' learning outcomes reflected her 'steely determination and drive' to use 'as much achievement data as possible' to 'lock the boys down' and 'give the boys no room to breathe.'

Inextricably linked to this perception of boys' low performance was the Principal's equal resolve to 'stretch the high end' students (mostly girls) into the realms of 'excellence'. Here, the Principal purposefully sought out and personally signed off the provisioning of opportunities for 'highly able' girls to join SEAL classes mid-course by forcing them to drop 'non-essential' elective classes, including Maker technology subjects. In this regard, the Principal's top-down hierarchical push to improve boys' low literacy results and 'stretch' high-performing girls could also be read as a neoliberal effort to protect the school's hard-fought efforts to become a 'high performance' public school of 'choice'.

Power relations were also made manifest inside all classrooms. The mandating of teacher control of lessons using the 'default pedagogy' and controlled learning spaces made clear to students that power and authority rested with the teacher. However, this did not always apply in the Maker technology classes I observed (see Chapter 7). Rather, most Junior School Maker technology teachers were seen to go through the motions – rather than strictly enforcing - the 'default pedagogy' in their classes. This was mostly due to the Classroom teachers making a conscious choice to sideline the 'default pedagogy' as it was not suitable to the type of learning experiences students engaged with in these classes.

Finally, gender power relations were also read through my broader observations of the school's pristine surrounds, the tight regulation of student movement across and inside the school, the nature of songs played between classes with lyrics supporting traditional male and female roles and/or associations, and the rigorous application of spatial constraints - including timed segments inside

lessons using the school's 'default pedagogy'. Each of these aspects worked to lock in student dependence upon teachers, who, in turn were strictly controlled (and monitored) by the Principal and her leadership team who enforced the school's strict application of a standardised pedagogical model and regular testing regime.

Production gender relations

Connell's (2009) next gender dimension – production relations – links the production, consumption, and accumulation of resources. More particularly, this dimension of gender is found in the 'gendering of occupations' and 'the division of paid work and labour' (Connell, 2005, p.7). Within Greenfield College, Connell's (2005) production relations were discerned within a range of activities, including staff roles and responsibilities, students' subject choices, students' participation in co-curricular activities, student participation in leadership roles and camp programs.

As is the case in many government schools, there were more women teaching in the Junior School levels at Greenfield College. Without exception, women ran the hospitality centre, the canteen and filled all administration support roles. Conversely, men dominated facilities management, operations, maintenance, technology support and timetabling roles. Further, most senior teachers of STEM subjects were male, whilst almost all female teachers taught Senior English or Arts subjects. Junior Physical Education classes were separated by sex in Years 7 and Year 8 wherein male teachers taught boys and female teachers taught girls. Male teachers however taught all senior physical education and technology-based subjects, including robotics, engineering, physics, and chemistry. Disrupting this traditional gender order were the greater ratio of male to female teacher allocations of Year 10-12 Learning Leaders, and the presence of more male teachers of textiles, art, and drama. As of the beginning of the 2018 school year, the Principal class team consisting of an equal proportion of male to females, led by a female Principal.

Also contributing to gender production relations was the way choices of VCE subjects were restricted to traditionally male coded Maths, Science and Commerce subjects with very few Humanities, Arts or Media subjects on offer. Here the Principal and Teacher-Leaders advised this was due to school policy that required a minimum of eighteen students for a subject to run and student awareness of Arts and Humanities based subjects offered no competitive advantage in terms of the contribution to each individual student's final university entrance score. No male students elected to undertake female-coded subjects such as Literature, Textiles or Drama. However, many more female students

crossed-over into traditionally male-coded maths and science subjects, particularly as accelerated Year 11 SEAL students undertaking a Year 12 subject. This can be explained by students' awareness of subject scaling and the dedicated classes of SEAL students purposefully tracking towards an advanced Maths-Science pathway from Year 7, which sees these same students in Year 9 denied access to electives (such as Maker technologies at Year 9 or Year 10) as these students instead work one year above their peers in both Maths and Science subjects from Year 9.

Yet production gender relations manifested in most extra-curricular activities appeared more equally weighted albeit still academically focused on helping students achieve excellence. These included past student 'study buddies', external tutors teaching students after school, and guest lecturers or subject specialists offering advanced academic lectures. External organisations sponsored by a range of for-profit businesses and not-for-profit organisations also offered extra-curricular programs to students over the course of the year. Run by an almost equal mix of male and female presenters, these largely focused on offering entrepreneurial career support, academic enrichment, and personal growth, including mental health. In the lead up to the final exam period, all Year 11 and Year 12 students were required to attend and participate in a range of 'exam study boot camps' run by private external providers. Such sessions – prioritised over standard lessons inside the school day - included showing students how to 'be note-taking genius' and how to 'painlessly cram and smash your exams'.

The single largest exception to extra-curricular programs in terms of gendered production relations was the School Production, which was mostly dominated by female students, many of them performing male roles. Greenfield College did not have an overly subscribed sporting program. Of the few inter-school sports that did run, boys' teams of soccer and rugby dominated. School camps were also a compulsory feature of all Year 7 and Year 8 classes. Here three experienced male outdoor education teachers were responsible for running the school's program, wherein female teachers acted in a support role. Overall, production gender relations as discerned from Greenfield College's various programs appeared to largely reinscribe traditional binary essentialist and social constructionist categorisations of gender. Female students – particularly SEAL students – undertaking advanced Maths or Science subjects appeared to be one of the few challenges to this traditional order.

Emotional relations

Connell's (2009) third dimension of gender – emotional relations – was apparent in the ways students and teachers experienced gender relations around Maker technologies in the school. In her description of the application of this dimension in non-education organisations, Connell (2009) refers to solidarities, antagonisms, feelings of injustice, resentment about change, and feelings of betrayal (p.865). More particularly related to Greenfield College is Connell's (2006b) description of a 'depolarized workplace' caused by a decline in 'gender solidarities … associated with a cooler emotional tone in the workplace, an individualization of identities' (Connell, 2006b). Found in the observations outlined in Chapter 7, I suggest the existence of a masculine school climate not because of the presence of overtly hegemonic masculine aggressions or expressions of masculine entitlement, but rather due to the busyness and organisation of workflows inside the school gate which reward individualistic and unreflective characteristics focused on task completion as measures of student (and teacher) success rather than facilitating opportunities for collaboration, cooperation or reflection, notions aligned more closely to the feminine (see Chapter 3). As previously mentioned, the tight sociomaterial and spatial control over student choices, particularly affirmed by the repeated rhythms of the school's 'default pedagogy' and determination for students to 'live' the school's ethos of 'high performance', 'excellence' and academic 'success', provided few opportunities for students to work together or reflect upon their lived experiences with Maker technologies.

Students' social relationships within the seven Maker technology classes observed in this study also highlighted neoliberal tropes of gender operating as an organiser of relations. In the Junior classes, particularly Year 7, evidence of depolarisation was stark. Although sitting close to each other, there appeared to be little warmth in student relationships. Elements of anxiety, competition and even fear surfaced amongst the girls, particularly when undertaking standardised test assessments. Yet here too there were some exceptions, with one Year 7 girl proactively crossing into masculine spaces when the class was completing *SCRATCH* programming exercises to help boys struggling with this same task. Also, evident in all Maker technology classes from Year 7 to Year 10 were girls supporting each other within female spaces. In Year 9, on the surface depolarised student relationships appeared to exemplify Connell's 'individualization of identities' yet even here, girls sitting in amongst boys found a way to support each other, even without speaking.

Of most interest regarding Connell's (2009, 2002) third dimension of emotional relations were the three girls sitting in the Year 10 Robotics class described in Chapter 7. Like the excited, driven Year 8

SEAL girls, the three Year 10 Robotics girls demonstrated solidarity and confidence derived from emotional relations. In this class, the three girls chose to support the other with warm humour, conversation, and moral support throughout nearly every lesson I observed. This habit was also noted (but not acted upon) by the male Year 10 Robotics teacher who I noticed chose to keep his distance from the girls for EO reasons already mentioned.

Demonstrating a very strong sense of gender solidarity, again through their visceral (and positive) articulation of emotional relations, were the four Year 8 SEAL girls who openly shared their roller coaster of emotions when building and programming their *EdCreate* 3D Printer. Given permission by their teacher to take themselves away from the spatial and sociomaterial restrictions and constraints of their peers, these four girls exhibited every emotion that was the antithesis of those expected – and encouraged – by the restrictive structures and cool pedagogic conditions of Greenfield College. Instead of working as individuals, the girls' collaborated and cooperated as a team; competition was replaced with sharing a common goal; unthinkingly rushing toward an endpoint was replaced with quiet – and sometimes loud – reflection and debugging; and both fear and anxiety were replaced with a cacophony of exasperated groans - squeals of joy - and laughing, as each proudly contributed to the accomplishment of each successive challenge.

Yet as I observed classes from Year 7 going up to Year 10, I also noted a shift toward cooler, more depolarised relationships amongst all students at the older year levels, with more students appearing to focus inward, especially when in class. This was encouraged by the provision of few opportunities inside lessons for students to engage in collaborative or cooperative learning activities, as dictated by the requirement for all classes to use the 'default pedagogic' time stamps governed by school policy and monitored by school leaders. Unhelpful here too were the school-wide restrictions on student movements inside classrooms and rearrangements of furniture that may have otherwise encouraged collaborative conversations.

Yet, exceptions to this cool climate were observed in the Junior School Maker technology classes, as many girls defied the breakdown their solidarities and, at times, reached beyond themselves and their individual needs to help and support to their peers. Of significance here too was the way Junior School Maker technology classroom teachers - both male and female - made this possible by quietly defying the school policy expectation for all classroom teachers to follow the 'Default Pedagogy' and their accompanying quiet refusal to set a 'cool emotional tone' in their classrooms.

Symbolic Relations

Connell's final dimension of gender relations - symbolic relations – refers to the way gender identities are defined in culture through language and symbols of gender difference, prevailing beliefs, and attitudes about gender (Connell, 2005). Amongst the suite of internally produced texts and document artefacts used by the school for marketing purposes, most appeared to carefully orchestrate a picture of the school that spoke of the values underwriting the school's ethos: high performance, excellence, success, and outstanding achievement. In this regard, newsletters to parents, marketing materials such as prospectus documents, the school website and broader community publications all appeared consistently concerned with providing an equitable mix of male and female students wherein the activities or surrounds of students in these photographs were suggestive of gender neutrality in terms of written words, colours, background graphics and activities. This accords with Connell's (2006b) suggestion that photographing students in this manner is purposefully limits indicators of gender difference, which again aligns with the neoliberal logic that gender equity has been achieved, and it is the individual who matters.

More suggestive of the presence of hegemonic masculinity in the school are the school surrounds, both internal and external. As outlined in Chapter 5, these landscapes can be read through the clean, ordered, symmetrical straight lines that carefully zoned the school into its various active and passive spaces, the stairwells with their painted hazard yellow lines to keep students apart, military dark grey paint hues and standardized organization of furniture inside classrooms. Reinforced by the absence of colour, displays or any sense of emotion in student classrooms, blank canvas corridor spaces and stairwells, a cooler emotional tone was set in Greenfield College focused symbolically on the 'individualisation of identities' (Connell, 2009).

Also telling were observations of the school's external surrounds and the revamped covers of the first few pages of the school's Yearbook since the 2000s. Notable in both was the progressive stripping away of more than thirty years of the School Yearbook celebrating a mix of sporting and creative student endeavours in its opening pages, particularly student writing. Starting in 2003, the front cover and first several pages once reserved for student poetry and short stories were instead used to celebrate individual student academic success, always accompanied by colourful banners reinforcing the values associated with the school's ethos. Here, individual photographs of girls dominate, flanked by bold subtext declaring the results and post-school tertiary destinations. Other

photographs of students participating in corporate sponsored school activities, or students sitting or standing alongside visiting politicians or other significant persons also hold pride of place, with each serving as a subtle yet constant reminder that the school's ethos is deeply – irrevocably – entangled with the external socio-political context and its adherence to postfeminist and neoliberal binary understandings of gender.

As already mentioned, these neoliberal postfeminist proclamations of individual success were also publicly declared on the giant corporate advertising boards tied to the school's front fence, each proudly punctuating the full breadth of Greenfield College's main road frontage each December, soon after the release and publication of Year 12 VCE final examination results. These boards, complete with the faces and scores of 'high achieving' VCE students dominated at the top by higher ranked female students, occupy pride and place next to the school logo. These same boards are brought out again six months later, albeit this time flanked by a same sized advertising board inviting prospective parents of the 'next cohort of high-achievers' to sit the 'highly competitive' Year 7 'SEAL Entrance Examination', a pathway to 'academic success'. These secondary boards also contain more photographs of girls than boys, consolidating not only the symbolic suggestion that the school produces 'Successful Girls' but also reassuring prospective parents who may know of the school's reputation some three decades ago, that Greenfield College's dark days of being a 'a tough place with poor attendance, low performance, and almost zero expectations' are very much a distant memory.

9.5 Summing up and looking forward

To begin to make sense of this study, I have drawn from the theoretical insights presented in Chapter 1, Chapter 2 and Chapter 3 to the findings outlined in Chapter 5-8. In doing so, I have situated the Greenfield College ethos within its broader historic, economic, and political context. Then, by drawing from the feminist theories outlined in Chapter 3, I have endeavoured to render visible some of the hidden points of tension associated with gender that may account for girls' engagement with Maker technologies in Greenfield College. In doing so, I made no attempt to foreclose the points of tension I raised, nor create a single coherent explanation, as this is not the intent of this thesis. Rather, my combined application of theories has simply sought to explore how abstract aspirations of Maker Education inevitably encounter broader social and political contexts that reshape the meaning and nature of girls' engagement with Maker technologies is, and what girls' engagement with Maker technologies can be.

In the final chapter, I will provide the final consideration that this thesis had been leading toward – i.e., the question of what girls' engagement with Maker technologies in schools might tell us about the gendered nature of contemporary schooling and technology. This chapter provides for a broader scale consideration wherein specific findings will be left behind as I instead enter discussions – again theoretically informed – about how the understandings of gender that shape and influence girls' engagement with maker technologies located by this study might be considered 'otherwise.'

Chapter 10. Conclusions

In many ways this very specific local case-study has turned out to be less about Maker technologies in schools and more about the messy reality of gender in contemporary schooling. It has revealed that the gendered nature of contemporary schooling and its relationship with technology is as much filled with tensions as possibilities, contradictions as convergences. Indeed, my 'wrestling' with the 'cultural, political, and economic tensions and contradictions in the typical narratives about Making' (Vossoughi, Hooper & Escudé, 2016, p.213) throughout makes clear the need for us to better appreciate how girls' engagement with Maker technologies in schools is neither a politically neutral endeavour nor are schools themselves a politically neutral backdrop, set apart, somehow operating in isolation from broader society.

Accordingly, this study's contribution to scholarly efforts to support the engagement of girls with Maker technologies - and STEM career pathways – does not end by offering a neat set of straightforward conclusions about how or why girls' engagement with Maker technologies occurs nor does it offer a simple 'mantra of what works' that affords future scholars the option of 'ignor[ing] structural inequalities in pursuit of better outcomes' (McKnight & Morgan, 2020). Rather, derived from the complex, messy picture I have painted of girls' engagement with Maker technologies in Greenfield College, I will instead propose a series of 'thinking otherwise' feminist interventions that may - over time - lead to the emergence of different kinds of 'agentive teaching and learning' (Vossoughi et al., 2016, p.227).

To preface this horizon thinking, I first summarise what the present study says about girls' engagement with Maker technologies in schools more generally. Thereafter, I outline why my application of theories and place-based methods is of value to future researchers. Finally, I conclude by offering several propositions to empower us to '(Un)School' gender and therefore better realise our efforts to engage girls' with Maker technologies - and STEM pathways - in schools.

10.1 What does this thesis say about girls' engagement with Maker technologies in schools?

In many ways, the present study found very little evidence of things changing with respect to girls' future engagement with computer science or engineering subjects and/or STEM career pathways flowing from girls' engagement with Making technologies. Yet, this was not because of deficits found in individual girls or classroom teachers or because of individual projections of gender bias. To the

contrary, girls' engagement with Maker technologies was influenced by a messy entanglement of structural, material, and pedagogical institutional factors, including:

- No coordinated effort was made to bring Maker technologies into the school.
- Short-term Year 7 to Year 10 Maker technology 'electives' were squeezed into an already overcrowded academic curriculum that prioritised 'high performance' subjects.
- Timetable arrangements prioritising the fast tracking of SEAL students blocked their engagement with Maker technology electives from Year 9 or Year 10 (or beyond).
- Classroom spatial and material configurations were incompatible with Maker Education.
- No storage spaces were provided for Maker technology classes, denying students' the option to spend more time Making and learning from the moment they arrive, until the moment they left class.
- The school's standardised 'Default Pedagogy' was incompatible with Maker Education.
- The school's assessment regime (testing) was incompatible with Maker Education.

This surface level of analysis attributes the school's institutional policies, practices and priorities derived (and legitimised by) Greenfield College's neoliberal ethos to girls' (non) engagement with Maker technologies in the school. This was made manifest by the way the school's all-encompassing focus on consolidating the school's brand - and reputation - as a 'high performance', 'high achieving', 'successful' school of 'choice' - made nigh impossible the prospect of girls - particularly 'high achieving' female SEAL students - ever taking up technology or engineering subjects in their future years at Greenfield College as advocated (and sought) by national government STEM policy initiatives.

This endpoint signifies a significant departure from most conclusions drawn about student engagement in the Maker Education literature surveyed in Chapter 1. It also troubles wider societal assumptions that the solution to the problem of girls' engagement with Maker technologies and/or STEM subjects or career pathways lies in correcting 'deficit' views of girls' relationship with STEM subjects or career pathways, or quelling the influence of gender bias and stereotypes; all of which this study found are ironically perpetuated by government STEM publications and government education policies – including rationales for special funding initiatives distributed to schools and the broader community. Also challenged by this study are the accompanying deficit views of classroom teachers and the view that providing teachers with more professional training will fix 'the problem' of girls' engagement with Maker technologies described in Chapter 1.

However, this study also optimistically affirmed several salient points raised by Educational Technology scholars in Chapter 2 and feminist scholars in Chapter 3. This includes the positive implications of classroom teachers offering emotional support to students engaging with Maker technologies and students generating this same relational support amongst themselves. Further, four of the seven classroom teachers observed for this study affirmed the positive impact on girls' engagement with Maker technologies when classroom teachers opted to become – to various degrees - 'agents of disruption'. This was realised by each classroom teacher's easy decentring of authority, exercise of a 'relaxed sense of control' and seamless 'manoeuvring' to find 'in-between' spaces where female students could engage more authentically with Maker technologies; with each feature aligned to feminist pedagogical practices outlined in Chapter 3. In this intervention space, located somewhere between the school's expectation of a 'cool climate' and classroom teachers' requirement to deliver learning to their students using the school's 'Default Pedagogy' and prescriptive assessment regime – girls at Greenfield College were witnessed working together, making mistakes, taking risks, openly expressing their emotions, debugging, reflecting, improving their technical skills and moving freely around (and outside) their designated classroom spaces.

Yet, the fact that this disruption was temporary and amounted to only a few Year 8 SEAL girls working together for a couple of weeks on the floor of a Year 12 student kitchenette – or a Year 9 Electronics girl quietly fist pumping her success down by her side after debugging an electronic project her way – or Year 10 girls successfully completing their Year 10 Robotics coursework because of their benevolent teacher's deficit views of their technical abilities - also forewarns that this study's slightly better understanding of the relationship between technology and the gendered nature of contemporary schooling has barely scratched the surface in its attempt to deal with the 'complex struggle that lies beneath' (McKnight, 2015, p.925).

10.2 The benefits of thinking with theory

Thus, the question for this study now becomes 'where to now?' As established in early chapters, the purpose of these thesis from the outset has been to do more than simply describe the 'what' and 'how' of girls' engagement with Maker technologies. Rather, it has listened to advice from early and contemporary Educational Technology scholars who advocate for a more thorough application of

theory to make sense of how, what, where and why Educational Technology (i.e., Maker Education) is happening in schools.

Thus, as an example of 'what could be' in future Maker Education studies, the present study's mix of feminist theoretical perspectives with the thinking of historic and contemporary educational technology scholars exemplifies how 'thinking with theory' afforded three equally significant layers of analyses: first, it allowed the discernment of how Greenfield College is emplaced within its broader social and political context; second, it surfaced how contradictory understandings of gender lived within – and outside - Greenfield College; and third, it afforded an opportunity to develop more thorough understandings of how both the institutional and pedagogic conditions living inside Greenfield College shaped and influenced girls' use of Maker technologies throughout the school.

Furthermore, the present study's engagement with these theories greatly informed my efforts to strategically map out then slice through the 'messy and bumpy textures [and] terrains' (Wheatley, 1994, p.413) of the huge corpus of found and research-generated datasets collected by this study. Here applying theoretical insights worked as 'both a point of reference and a point of correction' (Selwyn, 2012a) by ensuring I was constantly ask[ing] more pointed and difficult questions' (Philip & Garcia, 2015) of the design and application of the current study's methods and procedures, and the interpretation and analyses of the rich corpus of data that later ensued.

More specifically, engaging with the scholarship of early and contemporary educational technology scholarship made clear that I should expect – and indeed relish –the 'messy' social reality of technology use in schools as this would demand of this study the need to scrutinise more closely the structural, spatial, material and therefore political dimensions of schools and schooling at the micro, meso and macro level. Significantly raised too was the need to seek out and analyse how political 'situational constraints' entangled with the use of Maker technologies. Particularly useful here was Monahan's (2001, 2005) advocation for researchers to closely examine the material context and 'built pedagogies' of schools. This led the present study closely examining technological artefacts, spaces, infrastructures, and discursive contexts related to individual relationships, school organisational communications, policy negotiations and symbolic contexts that encompass cultural meanings and logics associated with school artefacts, images, discourses, and processes.

Similarly useful was educational technology theoretical advice advocating researchers spend more time attuning themselves to the 'ebb and flow' of multiple factors, relationships and individual,

organisational, pedagogical, and technology-related variables associated within their fieldwork sites rather than simply identifying then cataloguing each of these factors in isolation. Here the advice of spatial and material educational technology scholars who proposed researchers scrutinise external entanglements, including the influence of government agencies, societal institutions, local community organizations, the school bureaucracy, external agencies, social and political institutions, and external consultants advocating new pedagogies or resources proved essential.

With regards to theoretical perspectives on gender, this thesis found invaluable the insights drawn from the full range of feminist theories outlined in Chapter 3. Each helped progressively develop the idea that Greenfield College's enactment of Maker Education is inevitably stymied by the multiple ways gender is understood – and operates - in the school. This meant the present study's engagement with feminist theoretical perspectives throughout this study enabled: (1) the identification of how gender is expressed in visible and hidden social structures, practices and policies of Greenfield College; (2) the discernment of how characteristics associated with each of these understandings supports or blocks the prospect of gender equality; and (3) the location of sites for disruption and feminist interventions that may better realise attempts to lift the number of girls taking up STEM subjects and STEM career pathways using the conduit of Maker technologies.

10.3 The benefits of using place-based methods

My engagement with material, spatial and feminist theories was also central to my decision to use a place-based methodological approach in this study. Thus, future scholarly engagement with 'place-based' methods when undertaking investigations of Maker Education in schools offers a useful response to the question of 'where to now?' In the case of the present study, place-based methods ensured the present study refused the prospect of treating Greenfield College as a 'separate thing unto itself' or 'neutral background' to the 'action' of Maker technologies being used in Greenfield College, particularly by girls. It also ensured the present study developed a sufficiently thick understanding of how the social, political, and economic context of Greenfield College influenced the introduction and use of Maker technologies in the school. Furthermore, by rendering visible the otherwise hidden – or taken for granted - school structures, practices, processes and policies, the application of feminist theories to scrutinise these thick descriptions helped the present study make better sense of how gender shaped and influenced girls' engagement with Maker technologies. Last, place-based methods afforded an opportunity for the current study to discern how the particularities

of individual schools enter 'the ways that the people in the school make sense of where they are, and to recognize the kinds of spatial, temporal, material and discursive processes that shape the school world' (Thomson & Hall, 2017, p.26).

Yet perhaps most significant is applying place-based methods simultaneously ensured that the present study both negated the prospect that this thesis would (re)territorialize girls' non engagement with Maker technologies as a problem for individual students, teachers, or leaders, to resolve whilst also potentially opening the door to better comprehending 'what is unique to the schools *and* what is common to all schools, which is also significant when planning interventions' (Thomson & Hall, 2017).

10.4 Thinking otherwise with feminist interventions

Since the mid 1980s, scholars across a range of education fields have expressed concerns about the impact of neoliberal market agendas on schools, particularly at the local level where the possibility of feminist 'gender equality' interventions could be – but often are not – implemented. In this sense, the pervasive influence of neoliberal economic agendas in schools – including Greenfield College - makes this study's contemplation of 'thinking otherwise' difficult to ponder, particularly given the present study was undertaken in an era when current neoliberal education policy agendas remain heavily focused on competition, accountabilities, funding concerns and academic performance targets (see Chapter 3). Indeed, as outlined in most chapters explored in this thesis, these neoliberal dispositions are readily discernible in Australia's national education policies, particularly in government efforts to transform government schools into competitive entrepreneurial actors who have no choice but to develop a school ethos that reflects the neoliberal market-driven agenda which celebrates students' individual successes and achievements only in economic terms at every available opportunity.

Yet despite this acknowledgement that neoliberalism has - and will - continue to permeate, marketise, and individualise schools to the point that all appear 'dissolved in the acid bath of competition' (Beck, 1992), the present study still holds the view that feminist interventions focused on transformation can be applied to the relational gender structures identified by this thesis. For this reason, Stephen Ball's (2020) view of the 'impossibility of education' (p.876) and the 'inevitability of failure' (p.877) is refused. Instead, inspiration is drawn once more from feminist scholars, particularly Jessica Ringrose (2013) who argues that it is incumbent upon feminist educators and researchers

alike to search for and operationalise ‘otherwise’ interventions irrespective of the political context we find ourselves operating in.

Thus, significant to the ‘otherwise’ thinking the present study now proposes is the conviction that identifying how competing and contradictory understandings of gender live within and outside contemporary schools and our processes of schooling in the manner undertaken by this study is an important first step. This means equipping educators, policy writers and researchers with the capacity to identify how various understandings of gender live within school institutional structures and pedagogical practices as much as within individuals. As described in Chapter 9, in Greenfield College four main understandings of gender were found: biological essentialism, social constructionism, post feminism and neoliberal feminism. Further, common to each staff member interviewed for the present study was a lack of awareness about how the school’s material, spatial and social structures – as reinforced by external relational entanglements - stymy otherwise well-meaning efforts or actions to address gender inequality throughout the school.

Yet this lack of awareness should not be viewed as negative, noted then discarded. Rather, it should be conceived as raising optimistic possibilities for intervention which first require an acceptance by the school that delimiting surface-level, historic understandings of gender identified in the present study – exclusive teaching and learning processes, resources, issues of access, role models or an individual’s attitudes and behaviours – are neither permanently cast, static, and assured nor incapable of change. Rather, as this study has shown, these gender structures are relational ‘patchworks and heaps of fragments rather than well-oiled machines [that] still shape people’s lives’ (Connell, 2021, p.77). Shifting this understanding means once these restrictive understandings of gender are identified, opportunities arise to change the gender structures operating in the school. Hence, the present study proposes educators, policy-writers and researchers first surface the social structures where gender lives then cast each anew as either potential sites for enabling or disabling change, or as sites to 'manoeuvr[e] within post feminism’ in a manner that 'negotiate[s] between hegemonic, postfeminist discourses on the one hand, and marginal and potentially subversive discourses on the other' (Utoft, 2020, p.301).

Having addressed the ‘where we are now’ and the need to reorientate mindsets, some preliminary thoughts are now offered on the bigger question that this thesis has been leading toward, ‘where is it possible to go to from here?’, which the present study now argues has emerged as a direct

consequence of applying the theories and place-based methods used in the present study. Whilst none of the interventions henceforth suggested are intended to be an exhaustive treatise by any means, each proposed intervention is conceived of as an opportunity to open the door – if only a centimetre or two - to changing the restrictive continuity of (neo)liberal social constructionist categorical perspectives on gender which otherwise stymie girls' engagement with Maker technologies and – potentially - STEM subjects and career pathways.

Name the girls (and women)

In much of the Maker Education, Educational Technology and Educational Policy scholarship discussed in this thesis, and increasingly in Australian education policy more generally, there exists a tendency to use ungendered titles and therefore individualised politically neutral conceptualisations of 'students', 'teachers' and 'leaders'. This is symptomatic of what Connell (2011) calls the 'indirect neutralising gender politics of neoliberalism' which denies the pursuit of social justice in relation to gender because the unnamed 'individual' is rendered invisible, possessing no gender, as the market delivers instead advantage to the smartest entrepreneur, not to men or women as such.

This point is also underscored by Enloe (2014) who warns that any time researchers are denied the option to exercise their feminist curiosity by the anonymising practices of scholarship, the 'fog [of] uncuriosity' (p.4) enunciates a missed opportunity to examine the extent to which organisational structures and beliefs privilege masculinity and if - or how - this impacts girl (or women). For this reason, my first 'thinking otherwise' proposition argues for future researchers to simply make more explicitly visible - then disrupt - the politics of gender operating through and in educational policies and schools by foregrounding where girls (and women) are positioned in schools, who put them there, and the various policies and processes that maintain these places.

Clearly indicate what 'gender' means

The problem of what scholars, educators and policy writers mean by 'gender' in academic scholarship has long been a point of contention for feminist scholars (see Chapter 3). For example, in the body of work drawn upon in this study, no explicit identification or definition of what is meant by 'gender' was found in any Maker Education or Educational Technology or Educational Policy study. Rather, this 'taken for granted' term was mostly found used as an adjective or noun referring to binary categories of sex differences both in the academic literature surveyed in this study, internal school responses to government policies, government publications promoting girls' engagement with

educational Maker technologies and indeed throughout staff interview responses described in my Findings chapters. This pervasive uncritical application of the term 'gender' necessarily promotes static and assured understandings of what we know to be a politically charged concept. This renders prohibitive the possibility of researchers seeking out 'otherwise' sites to locate feminist interventions to better address equality concerns; especially when combined with the relative lack of interest in exploring gender in relation to the political economy of schooling in Maker Education, Educational Technology and Educational Policy scholarship canvassed in Chapters 1 and 2, thus rendering difficult raising opportunities for change.

Thus, in the spirit of this study's 'thinking otherwise' my second proposition argues for scholars to make clear what is meant by gender when using the word in their studies. This will refuse the option to further consolidate apolitical fixed categorical understandings of gender. Rather, scholars could instead focus on how gender relations nest in the lived social, economic, and political context of 'school' sub-structures and 'schooling' practices. Of course, this 'otherwise' positioning requires researchers to ask many, many more questions of their school research sites and of what others often take for granted about gender inequality - including the role of history and agency in the formation of the school's organisational structures – and the proposition that girls' (non) engagement with educational Maker technologies arises inevitably due to essentialised, deficit attributes associated with individual girls, teachers, leaders, or schools.

Improve 'gender literacy' to locate school gender regimes

The alternative feminist imaginary thus far suggested requires an improvement in educator, policy-writer, and researcher 'gender literacy' so that all are equipped to locate where categorical, biological essentialist understandings of gender live within a school's organisational structures and practices. Accordingly, this requires raising school leader, teacher, and student awareness (and literacy) of how and where biological essentialist categorical understandings of gender are implicated in the formation, maintenance, and perpetuation of localised gender understandings or the masculine 'cultural arbitrary' (Archer, 2017, p.121) that otherwise continues to pathologise the 'problem' of girls' engagement with Maker technologies (and allied STEM subjects) as something for individual girls or teachers to resolve.

My advocation of this feminist intervention is not new. As outlined in Chapter 3, Connell (2002, 2009) has particularly argued that 'deinstitutionalising' categorical understandings of gender in schools

requires the raising of awareness in a school - and across school systems - about how the four dimensions of gender relations applied in this study - production, power, emotion and symbolic – nest in a school's organisational sub-structures, operate within the school, and also enter then leave (then sometimes come back again) through the school gate via the school's broader gender order relational entanglements.

Thus, to deliver upon my third 'thinking otherwise' proposition, I would argue schools implement Connell's (2009) plan to affect this goal. This can be achieved by actively: (1) seeking out opportunities to deliberately locate gendered organisational structures that require addressing so their reach is reduced to zero; (2) weakening the internal couplings between gender patterns of inequality in one domain of organisational practice so they cease to inform gender patterns in another; and (3) considering the interplay of gender equality reform policies enacted by state agencies with a school's own gender regimes. Doing so would ensure researchers, educators and policy writers develop a 'thicker' gender literacy to help each recognise how state sanctioned 'gender' equality policies and initiatives - including the use of Maker Education to schools to lift girls' engagement in STEM - can be complicit in perpetuating 'powerful … quintessentially masculine' cultural narratives that 'produce women as deficient' in STEM areas (Becky Francis et al., 2017, p.172).

Monitor Gender Mainstreaming

As outlined in this study's early chapters, over the past several years the Australian Government has played a significant role in shaping aspirations (and expectations) that educational Maker technologies hold the potential to lift the number of girls engaging in STEM subjects and/or career pathways. Running in parallel to these efforts have been government efforts to formalise its global commitment to lifting the number of girls engaging in STEM subjects and/or career pathways using the OECD's Gender Mainstreaming strategy. Yet to date, still absent in Australia's application of GM are the required efforts to *analyse institutional structures and processes* to locate gender.

For this reason, my fourth 'otherwise' thinking proposition argues for the government to expend less energy developing neoliberal policies to monitor teacher accountabilities and lift school efficiencies, and more on assisting schools to complete a gender regime report (as described throughout this thesis). This would encompass building up institutional understandings of not only how meanings of 'gender' are activated and legitimised in schools but also where delimiting categories of 'gender' reside inside internal structures, processes, and practices (and how these could be reorganised) in

schools. Also required is closer scrutiny of how understandings of 'gender' are consolidated through written, verbal, and symbolic language used in and beyond schools when enacting policies, protocols, practices, and the organisation of materials and spaces within and beyond the school gate. By addressing each of these aspects, the gender equality spirit of gender mainstreaming will be provided with a better opportunity to systemically infuse the social structures of schools *and* schooling that give rise to - and are still perpetuating - gender inequalities in the first instance.

Disrupt postfeminist & neoliberal feminism at the local level

As outlined in Chapter 3, Jessica Ringrose (2013) argues for a disruption of the postfeminist gender 'equality illusion' that has 'infiltrate[d] and shape[d] the political and policy domains of education (2013, p.5). Maintaining that neoliberal educational discourses and practices have directly contributed to postfeminist notions about female power and success by 'restabilising binary constructions of male and female' (p.7), particularly when shaping representations of girls as either empowered consumers/winners or vulnerable victims (p.4), Ringrose optimistically asserts that even though schools are steeped in 'neo-liberal, competitive, performative audit cultures' wherein 'student/school performance in league tables takes precedence over all aspects of socio-political life' (p.144), there is still room to find spaces of hope where gender 'undoings' might emerge.

Accordingly, Ringrose (2013) argues the case for finding 'some spaces where gender 'undoings' [can] emerge' (p.147). Here the adoption of a whole school approach is proposed, one that disrupts neo-liberal logics of performance targets, audit cultures, accountabilities, and individualised competition and creates equal space for gender equality and academic-based performance to co-exist on equal terms. In recognition of the difficulties either proposition suggests, Ringrose (2013) further advocates for scholars, educators, and policy writers to 'search through every space that we are operating in to find where thinking, hoping and becoming otherwise might be possible' (p.149). In this regard, this study argues for the enactment of localised approaches – such as replacing the straitjacket of standardised pedagogies with feminist pedagogical approaches - to temper the neo-liberal logic of individualised competition that is otherwise transforming our schools into 'entrepreneurial actors competing for performance-based results to garner resources' (Ringrose, 2013, p.149).

Promote gender democracy

As demonstrated by the present study, to realise the promise of gender democracy in our schools, required first is an analysis a school's organisational structures, processes, and practices - as

understood in its local and broader context - to make visible the social structures that perpetuate gender inequality. This is because it is in these places that the promise of feminist interventions can also sit. Here Connell (2009) suggests that when thinking about how we might realise gender democracy - a move toward equality of participation, power, and respect - we first position ourselves to accept that gender social structures are unstable, they are subject to internal and external pressures, and it is possible for us to weaken them by enacting 'an internal uncoupling' (p.98). Thus, once the location of gender social structures, practices and processes we wish to 'uncouple' have been discerned, one domain of gendered practice can then be supplanted with another that better realises gender democracy.

Such possibilities are particularly exemplified by Richardson's (2015) analysis of alternative schools who deliberately seek to implant more democratic, more human-facing, and more relational educational practices by purposefully distancing themselves from the reductive practices of 'sextyping' - 'the act of stereotyping what an individual's preferences, likes/dislikes, interests, abilities, are according to the individual (assumed) sex within the traditional male/female binary' (p.23). In these alternative democratic gendered spaces, the mainstream habit of 'doing gender to' students by quarantining them by age or sex, then subjecting them to universalising, standardised 'guaranteed and viable' curriculum programs, formal lessons and common assessments is replaced with an understanding that sees each student as both unique and relationally similar (human) and dissimilar (individuals) to others. Over time, teachers and students working in these alternative democratic spaces learn who they are in relation to others in multi-age and multi-gender groups, engage with classroom teachers who understand themselves to be guides, and access uninterrupted blocks of time to undertake guided choices of work activities - individually or with peers - in spaces designed to encourage a sense of order and freedom that both imposes limits and encourages student independence.

Final thoughts

To realise the democratic potential of Maker technologies for girls in schools, this study argues for educators, education policy writers and future researchers to work collaboratively towards locating unstable gender social structures, leveraging identified pressure points to uncouple (neo) liberal gender practices, then supplanting each by applying one or more of the 'thinking otherwise' interventions explored in this study. This plan of action concurs with the view advanced by Jennifer

DeWitt, Louise Archer and Julie Moote (2019) who argue 'big changes are needed, not tweaks, if we are to shift the inequitable' and arrest the 'cultural arbitrary that underpins and reinforces' (p.1085) girls' (non) engagement with STEM subjects/career pathways more generally.

Accordingly, rather than simply advocating personalised solutions or better contextualising girls' experiences with Maker technologies the present study instead advocates for the application of the proposed 'thinking otherwise' interventions to 'undo', 'uncouple', disrupt then supplant the hidden (neo)liberal macro (and micro) narratives of gender operating in schools and schooling. Doing so will help ensure schools planning to implement Making technologies to expand girls' engagement with STEM and/or computing subjects or career pathways will no longer be complicit in 'muting' the very problem they are trying to resolve, gender inequality.

10.5 Limitations

As indicated in Chapter 4, there are several limitations to the current study that require acknowledgement.

First, the short duration of fieldwork undertaken in the present study means as an ethnography, it barely scratches the surface of developing our understanding of how gender shapes and influences girls' experiences of Maker technologies in Greenfield College. Thus, to draw more meaningful conclusions, a much longer period inhabiting the school, and following leader, teacher, and girls' engagement with Maker technologies across several classes, observing too the flow of relational entanglements inside, around and beyond the school gate, preferably over a number of years, is required.

Second, as a single case study this thesis uses far too small and distinct a sample to provide suggestions for a widespread generalisation of its conclusions.

Third, as outlined in Chapter 4, my inability to conduct planned focus-group discussions with girls excluded a pivotal layer of data, particularly given the present study's application of feminist theoretical perspectives. Thus, although the present study's experiences of girls with Maker technologies is a key focus of the present study, and my inclusion of vignette and empirical descriptions of girls do bear witness to girls' experiences in the classrooms I observed, this study's inability to provide girls with an opportunity to speak for themselves about their experiences with Maker technologies means the present study has rendered them an object of this study rather than a subject empowered to speak with their own voices. Relatedly, my own positioning, objectivity, and

selectivity as an observer – as outlined in Chapter 4 – has also impacted my interpretations, assessments, and analyses of girls' experiences with Maker technologies.

Fourth, this study did not have an opportunity to explore the intersections of gender and race, class, sexuality, and/or other social divisions such as religion, intersect with, shape, and position the experiences, identities, and roles of staff members and students in Greenfield College, nor of individuals who relationally entangled with the school as outlined in Chapter 5, in different networks of power.

Last, and relatedly, by not applying a feminist intersectional lens in the present study, no consideration was given to the dynamic complexities within binary categories of gender (male/boy and female/girl), the instability of these categories (male/boy, female/girl), or how these complex, unstable intersectional notions of gender relations operate between, within and through different social structures in the school to shape and influence girls' engagement with Maker technologies. This is significant given an intersectional analysis can produce insights into how gender relations work in a particular context by illuminating how multiple inequalities interact with other dynamics of social life.

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Appendices

Appendix I – Monash University Ethics Approval Certificate

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID: 14260
Project Title: Making Schools - Realising the STEM potential of 'Maker' technologies in secondary schools
Chief Investigator: Professor Neil Selwyn
Approval Date: 21/08/2018
Expiry Date: 21/08/2023

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Assoc Professor Michael Henderson, Ms Rebecca Carter

List of approved documents:

Document Type	File Name	Date	Version
Explanatory Statement	v2BCA-Explanatory Statement-Prin-Admin-TS	06/08/2018	v2
Explanatory Statement	v2BCA-Explanatory Statement-Teachers	06/08/2018	v2
Explanatory Statement	v2BCA-Explanatory Statement-Students-Parent-Caregivers	06/08/2018	v2
Consent Form	v2BCA-Consent- Prin-Admin-TS	06/08/2018	v2
Consent Form	v2BCA-Consent-Teacher	06/08/2018	v2
Consent Form	v2BCA-Consent_Student and Parent-Caregiver	06/08/2018	v2
Explanatory Statement	v3-Revised-BCA-Explanatory Statement-Students-Parent-Caregivers	16/08/2018	v3-Revised
Explanatory Statement	v3-Revised - BCA-Explanatory Statement-Teachers	16/08/2018	v3-Revised
Consent Form	v3-Revised-BCA-Consent-Teacher	16/08/2018	v3-Revised
Consent Form	v3-Revised-BCA-Consent_Student and Parent-Caregiver	16/08/2018	v3-Revised

Department of Education & Training

2 Treasury Place
East Melbourne Victoria 3002
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2018_003821

Ms Rebecca Carter
Faculty of Education
Monash University
Scenic Boulevard and Wellington Road
CLAYTON 3800

Dear Ms Carter

Thank you for your application of 27 August 2018 in which you request permission to conduct research in Victorian government schools titled *Making Schools - Realising the STEM potential of 'Maker' technologies in secondary schools.*

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.

1. Department approved research projects currently undergoing a Human Research Ethics Committee (HREC) review are required to provide the Department with evidence of the HREC approval once complete.
2. The research is conducted in accordance with the final documentation you provided to the Department of Education and Training.
3. Separate approval for the research needs to be sought from school principals. This is to be supported by the Department of Education and Training approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.
4. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Training for its consideration before you proceed.
5. As a matter of courtesy, you advise the relevant Regional Director of the schools that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.
6. You acknowledge the support of the Department of Education Training in any publications arising from the research.

VICTORIA State Government

7. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study's indicative completion date.

I wish you well with your research. Should you have further questions on this matter, please contact Youla Michaels, Project Support Officer, Insights and Evidence Branch, by telephone on (03) 7022 0306 or by email at michaels.youla.y@edumail.vic.gov.au.

Yours sincerely

[redacted]

12/10/2018

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