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Design education in schools: an investigation of the Australian Curriculum: Technologies

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Abstract
Design education as a field is growing rapidly due to its potential to develop the capacity of students to become creative and imaginative thinkers. In addition to these key twenty-first century skills, design education can also equip students with problem solving skills and innovative capabilities. The purpose of this paper is to build an understanding of how design is represented within the Australian Curriculum: Technologies document and critically explore effects of these representations within and between Key Learning Areas. The paper makes a contribution to design education in school contexts through an empirical analysis of curriculum documents to illuminate the complexity of the concept of design and the pedagogical implications of its multiple representations in this curriculum document. The analysis includes identification of the Key Learning Area in which design is most frequently represented across the Australian Curriculum. Content analysis with concept mapping are used to interrogate how design is represented within and throughout curriculum documents. We also undertake a critical examination of how design is positioned in the curriculum and the implications of such positioning. The paper argues the need for strong, unambiguous representations of design to inform curriculum and pedagogy. Clarity of the representation of design will contribute to the development of innovative capabilities in students and help to prepare them for an uncertain future.

Keywords Australian Curriculum · Design education · Design · Australian Curriculum: Technologies · Content analysis · Concept mapping

Introduction

Over the last two decades there has been an emergent focus on design "as an agent of change" (Stewart 2011, p. 516), and proposed as a key avenue for supporting students to develop twenty-first century capabilities, including creativity, innovation and problem-solving skills (Australian Council for Learned Academies [ACOLA] 2016; Howard 2008, 2016). Design education has been positioned as a central approach to equip students with

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the skills deemed to be critical to address the challenges facing society and our global context in the future (Berry 2012; Eggleston 2001; Duell et al. 2014; Wright and Wrigley 2019). Despite research highlighting the potential of design education to support the development of students' problem-solving and innovation skills (Carroll et al. 2010; Wright and Wrigley 2019), there is contention within research, curriculum documents, and schooling about how and where to effectively enact design education in the classroom. A critical issue in design education is that the definition of design is highly disputed (Davis 2017), resulting in a lack of clarity evident in curriculum documents, which holds substantial implications for pedagogical implementation (Christensen et al. 2019).

While research proposes the potential of design education it has been the fields of Science, Technology, Engineering and Mathematics (STEM) that have been central to the policy discourse of building innovative capabilities across Foundation to Year 10 (F-10) education in Australia over the past decade. The STEM agenda is clearly evident in the formal representation of education policy in the classroom, namely, the Australian Curriculum. This agenda has largely focused on the potential of STEM education to increase national productivity, create jobs, and enhance the competitiveness of the economy to secure Australia's future (Australian Government 2015; Education Council 2015; Office of the Chief Scientist 2013). Despite the Australian policy focus on STEM, research councils and education boards (recently for example, the NSW Education Standards Authority Game Changer Challenge) are beginning to recognise that knowledge and technical skills within STEM disciplines are necessary but not sufficient to meet future innovation challenges (NSW Board of Education 2019). Increasingly, design education is viewed as critical in assisting to build students' creative problem solving skills and to help them solve complex challenges in readiness for future challenging situations (Goldman and Kabayadondo 2017; Razzouk and Shute 2012; Wright and Wrigley 2019). Students' engagement in design and design thinking it is argued is essential for creating innovative ideas and fostering twenty-first century skills (Wells 2013; Wright et al. 2018).

School education for the twenty-first century needs to develop a wide range of key skills in students, such as critical and creative thinking, complex problem solving skills, collaboration and the ability to respond to change (Lamb et al. 2017). Skills recognised in research as being developed within design education.

This paper examines design education within the official F-10 Australian school curriculum through an analysis of definitions and understandings of 'design' that are represented therein, with a particular focus on Australian Curriculum: Technologies. The purpose of this paper is to bring a comprehensive and critical lens to the curriculum document through the use of content analysis to answer the research question: How is design represented in the Australian Curriculum: Technologies? Specifically, it will consider how the lens of ideologies and power in curriculum (Apple 2004) can be used to interrogate how design is represented.

The history of design (and technology) in school education

Design education offers an approach to building soft-skills, including critical thinking and problem-solving (Wells 2013; Wright and Wrigley 2019). Simon (1969) distinguishes design from natural sciences, stating; "natural sciences are concerned with how things are… Design, on the other hand is concerned with how things ought to be, with devising artefacts to attain goals" (pp. 58–59). Archer (1991) also recognised

the potential of design explaining that design develops "the capacity for envisaging a non-present reality, analysing it and modelling it externally [which] is the third great defining characteristic of humankind, along with toolmaking and language use" (p. 8). Design is seen not just as the creation of new artefacts but as the interface between technology and people, which seeks to solve problems and develop new ways for people to interact in and with the world (Norman 2016). Design is viewed as a process that can be used to develop new and innovative technology (Katz 2015) and, as such, has been integrated as a component of the technology curriculum (Martin and Owen-Jackson 2013; Fleer 2018).

The emergence of 'Design and Technology' as a single curriculum area in compulsory education first occurred in the United Kingdom in 1990 as one of ten original subjects in their newly developed National Curriculum (Benson 2009; Eggleston 2001; Harris and Wilson 2004; Mawson 2003; Norman 1998). The new area of Design and Technology was innovative in its own right as it was seen as a transdisciplinary subject, amalgamating Craft, Design and Technology, Art and Design, Home Economics and Business Education into one subject with links to Science and Mathematics (Eggleston 2001; Miller 2011). The content of the curriculum focused on integrating practical skills and knowledge by following instructions, in order to design and make products (Martin and Owen-Jackson 2013).

The movement from the traditional curriculum area of 'Art and Design' to 'Design and Technology' meant that there was a need to align representations of design for a transdisciplinary curriculum. Instead, "design remained aligned with the arts but emerged as a new curriculum area with its own theory, emergent methodology and associated learning" (Grushka 2004, p. 3). Wells (2013) argues as a result these two traditional learning cultures "have tended to maintain parochial isolation making each the poorer by compartmentalising those essential elements that complement each other in the technical problem solving situations" (p. 626). Design and Technology has been defined by Eggleston (2001) as "using technology to achieve solutions that satisfy sound design criteria and using design to achieve solutions that satisfy sound technological criteria" (p. 24). Norman (1998) describes that the need to use 'design and technology' as a composite noun was a consequence of not having a word similar to 'technik' in English. 'Technik' in the German language means "the functioning of natural and man-made things and the methods used in their manufacture" (Fores and Rey 1986, p. 37). Norman (1998) argues 'technology' in English is not an adequate word to embrace the creation of the material world, beyond industrial culture and it is too closely linked to science, having potential implications for school curriculum. As a result, technology in school curriculum (which is represented in both 'design and technology' and 'information technology') is "inextricably linked with applied science" (Wells 2013, p. 623) and seeks to engage students by "learning about and working with traditional, contemporary and emerging technologies" (Australian Curriculum 2016, p. 4).

The introduction of Design and Technology in an Australian context was mandated in 1989 by the Hobart Declaration on Schooling which recognised 'Technology' as a key curriculum area (Banks and Williams 2013). The development of Technology education highlighted the shared belief that "technology education is vital for all students" (Williams 1993) and was an attempt to align current technology practice with "contemporary [international] developments in design and technology education" (Barlow 2012, p. 35). Within the 2010 Australian Curriculum, Design and Technology was amalgamated with Digital Technology or ICT (ACARA 2016). Critics of this change viewed it negatively expressing concern over how the coupling of subjects may create confusion about the nature of Design and Technology (Banks and Williams 2013).

Williams (2000) describes design within Design and Technology as a process for students to engage in when they do technological thinking. Design has four processes: problem solving, systems approach, invention and manufacturing. He goes on to state that "despite the fact that the terms design and problem solving are often used interchangeably, problem solving is different to design in that design deals with ill-defined problems and may not begin with a problem, while of course problem solving does" (Williams 2000, p. 53). Von Mengersen (2017) explains that there is no strict order in which design problems can be solved, as "there is no 'the' design process, only 'a' design process that is infinitely variable" as a result of the individual designer, how they approach problems and their approach to design thinking (p. 303). As evidenced by the literature, there is no single definition or interpretation of design within Design and Technologies in the curriculum illustrating its complexity as a subject area.

Initial perceptions of design in the Australian Curriculum

The Australian Curriculum was developed as a part of a vision to build a 'world-class' education system that would establish Australia "as one of the most highly educated and skilled nations" (Rudd and Gillard 2008, p. 5). In 2009, the Australian Curriculum and Reporting Authority (ACARA) was formed, with their primary remit being to direct curriculum reform guided by the goals and recommendations set out by the Melbourne Declaration of Educational Goals for Young Australians.

The development process of the Australian Curriculum consisted of four drafting phases, involving a panel of experts (ACARA 2012b, p. 6). As a result, representations of knowledge in the Australian Curriculum are described as being "constructed as a complex web of cross-hatched perspectives" (Doherty 2014, p. 178), due to the curriculum construction process. Peacock et al. (2015) argue that the Australian Curriculum attempts to focus on both what students need to learn and what they should become.

'Technologies' is one of eight Key Learning Areas (KLAs) in the Australian Curriculum comprised of two distinct but related subject areas, Design and Technologies and Digital Technologies (ACARA 2012a). Fleer (2018) states 'Technologies', is a separate curriculum that includes both Digital Technologies and Design and Technologies. The combination of these two learning areas provides a "new curriculum context for the learning of technologies in Australia" (Fleer 2018 p. 66).

Banks and Williams (2013) argue that this merging was "not seen as a positive development by technology educators and may confirm some of the confusion about the nature of design and technology" (p. 44). The link between the traditional Design and Technologies learning area and ICT, together with a shift towards a technologies-based curriculum has seen the dominant materialities move from the more traditional, 'manual' technologies such as woodwork originally present within Design and Technology to an incorporation and emphasis on the digital space.

The Australian Curriculum shaping and writing documents highlight initial perceptions and understandings of where and how design was intended to fit in the curriculum. The Draft Australian Curriculum Technologies states, "In the Australian Curriculum, design thinking and design processes feature significantly in Technologies, in particular Design and Technologies and The Arts" (ACARA 2013, p. 30). This draft document states that design is closely linked to the Australian Curriculum's general capabilities of critical and creative thinking. Furthermore, the draft document indicates that design thinking and

design processes are developed in the curriculum through "processes and production skills" (ACARA 2012a, p. 9). The Shape of the Australian Curriculum: Technologies explains design thinking as being the comparative difference between Design and Technologies and Digital Technologies in the curriculum (ACARA 2012a), highlighting that design thinking offers a distinctive way of knowing within Design and Technologies, although it is present within both subjects (Fleer 2018). The stated intention of the Design and Technologies elements of the curriculum focus on design thinking, whereas the Digital Technologies focuses on computational thinking to create solutions (ACARA 2012a, p. 8).

Design and Technologies is defined as having, "a strong focus on design thinking, the application of the design process and producing (making) solutions to design products, services and environments" (ACARA 2012a, p. 8). According to the curriculum, design thinking and design processes assist in developing design solutions (ACARA 2012a). Design thinking is defined as being primarily heuristic in nature (ACARA 2012a; Middleton 2005). It "includes strategies in order to understand design problems, generating creative and innovative ideas, and analysing and evaluating those ideas to find the best solution" (ACARA 2012a, p. 9). Solutions to design problems not only have to solve the problem, but also need to be creative (Crilly 2010; Middleton 2005). The ability to think creatively while designing is critical, as designing is not the result of "a set of pre-programmed events" or "a prescribed set of components" but depends on "conscious experience and discovery, in the moment response, collaboration interplay, decision- making, imagination, the "ah ha" moment, emotion, perception" which are all "representative of an individual's capacity to think creatively" (Wells 2013, p. 630). Design process within the curriculum involves students generating, developing and evaluating ideas, and designing, producing (making) and evaluating products to create design solutions for an identified user and purpose (ACARA 2012a, 2013).

Method

The purpose of this paper is to investigate how 'design' is represented within the Australian Curriculum: Technologies document and critically explore the effects of these representations. In order to do this, the paper examines how language is used in curriculum documents "as a system of socially shared symbolic meanings" (Burr 2015, p. 222) and how representations of design are shaped to hold a particular meaning within curriculum. Previous investigations into the Australian Curriculum have demonstrated that design and design-related concepts are most frequently represented in the Technologies curriculum document (Mosely 2019). Content analysis has been used to analyse the curriculum document to provide a detailed interpretation of the text and to provide insights into the conceptualisations of design and its representations. A content analysis approach involved the systematic investigation of the curriculum document through concept mapping, word frequency analyses, and the examination of design and design related concepts in text through coding categories that interrogate various representations of 'design'.

As a result of the content analysis, categories related to design were identified within the curriculum to identify representations of design. The most recent version (Version 8.3) of the curriculum, from the official Australian Curriculum website was analysed. To investigate 'design' in the Technologies curriculum, qualitative concept mapping and word frequency analyses were used to provide a flexible coding scheme with data-driven categories that can be investigated within the context of the text being studied (Schreier 2012).

Concept mapping was used to help create visual connections between each key learning area within the broader curriculum (Finfgeld-Connett 2014; Morgan and Guevara 2008). As Morgan and Guevara (2008) state, "the goal of concept mapping is to create an actual map where the concepts are represented as nodes, and the relationships between them are represented as lines that link those nodes" (p. 108). Repeated concepts or connections between certain concepts can illustrate emerging themes and specific connections within the text, to highlight certain representations (Morgan and Guevara 2008). Concept mapping revealed where design fits within the curriculum, the ideas, concepts and themes that it is connected to, and how these associated ideas are situated within the curriculum. The mapping process provided a strong background for the analysis of key words used in conjunction with design throughout the curriculum to help begin identifying the categories for a frequency analysis (Krippendorff 2013). Frequency analysis attends to the number of times the word 'design' and related terms were used, then recorded, interpreted and examined.

Concept mapping

Within concept mapping, meanings are located in the organisation of and relationship between concepts (Carley 1990). Examining the relationship between words and phrases through this 'relational analysis technique' can help develop a visual model to represent the overall meaning of a text (Wilkinson and Birmingham 2003, p. 79). Concept mapping in this investigation was used to visually represent data from the curriculum document "to condense the major data and findings from a study to further analyse and/or represent and present conclusions" (Miles et al. 2014, p. 107). Furthermore, concept mapping enables the data to be displayed in a focused, organised and systematic way supporting researchers' understanding (Miles et al. 2014). As such, concept mapping analysis helped to represent how codes, categories and themes related and fit together (Finfgeld-Connett 2014) to inform the next stage of the analysis.

Word frequency search

Insights gained from concept mapping informed the development of a coding framework and the identification of categories. Categories allowed further examination of which terms were associated with representations of design in the Technologies curriculum. Establishing a coding frame enabled researchers to "build detailed descriptions, develop themes or dimensions, and provide an interpretation in light of their own views or views of perspectives in the literature" (Creswell 2013, p. 184). Once categories were determined from the data, through the mapping process it was then possible to investigate the key words used in conjunction with design throughout the curriculum. An NVivo word frequency search was used to complement the concept mapping and reveal the dominant words in the text throughout the entire document (Gardner 2017).

Word frequency analysis was used to examine the frequency of the word 'design' and related concepts (Krippendorff 2013). This technique was used to determine how design was represented and how frequently design was represented within the curriculum document (Weber 1990). This process facilitated a critical analysis of their use within the text. Additionally, the frequency of the association of key words with design was recorded to identify their importance within the text (Wilkinson and Birmingham 2003) and the strength of their association. While word frequency analysis alone does not reveal much about the associations between concepts (Weber 1990), the approach facilitates critical

analysis of inferences created by frequent associations of these terms to design in the text, (Krippendorff 2013). The analysis process explored the ways categories interact and interplay with each other, particularly "how one or more categories might influence and affect the others, how categories operate concurrently" (Saldana 2011, p. 92). Uncovering these relationships required a systematic investigation of the data, beyond the word frequency count.

Critical analysis

Following the word frequency analysis, the identification of categories was systematically conducted across the Australian curriculum's Technologies document to highlight key categories that frequently occurred in relation to the word 'design'. These categories were cross checked against the concept mapping and initial word frequency search. Once dominant categories were recorded their use and the implications of such use were examined. At this point Apple's (2004) critical lens was applied in order to identify the inferences created by these categories. To ask why design is represented in certain ways and who benefits from these representations and finally question the implication of these inferences for classroom practice.

Understanding the position of design in the technologies curriculum

Beginning with concept mapping analysis of the overview section of the Technologies curriculum (Australian Curriculum 2016, pp. 2–9), we investigated how the two subjects (Design and Technologies and Digital Technologies) work together within the Technologies KLA covered by the curriculum document. This simple concept map was developed to illustrate Technologies content, and how key concepts and themes therein are clustered and linked (Fig. 1 below). The concept map highlights connections between key ideas across curriculum areas and shows how the two subjects have been constructed to work together, using design to connect the learning areas, and incorporating design thinking in technologies (Fleer 2018).

Initially each learning area within Technologies and the key ways of thinking was mapped (Fig. 1) to represent how various ways of knowing, including design thinking, systems thinking, and computational thinking, are intended to be integrated across the curriculum, in different contexts to reach solutions. The Design and Technologies curriculum

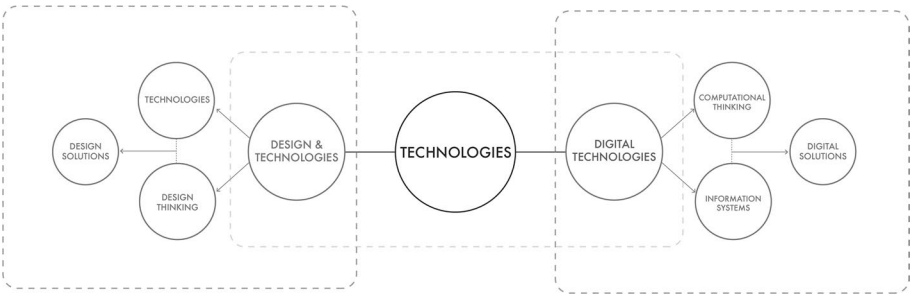

Fig. 1 Key ways of knowing in the Australian Curriculum: Technologies

states that students should use 'technologies' and 'design thinking' in order to achieve designed solutions. In the Digital Technologies curriculum, the intended curriculum requires students to use 'computational thinking' and 'information systems' to achieve digital solutions (Australian Curriculum 2016, p. 4). As design is common to both subjects in the Technologies curriculum (Fleer 2018), concept mapping was used to identify where design and design concepts were present and how they link the two distinct subject areas. The mapping of the Technologies curriculum overview revealed key categories within Design and Technologies and Digital Technologies that were associated with design, such as 'technologies', 'design solutions', 'processes and production skills' and' design thinking' (illustrated below in Fig. 2).

Design thinking is stated in the curriculum to be a crucial component of the design process as it "underpin[s] learning in Design and Technologies" (Australian Curriculum 2016, p. 5). 'Design thinking' is defined as "the use of strategies for understanding design needs and opportunities, visualising and generating creative ideas, planning, analysing and evaluating those ideas that best meet the criteria for success" (Australian

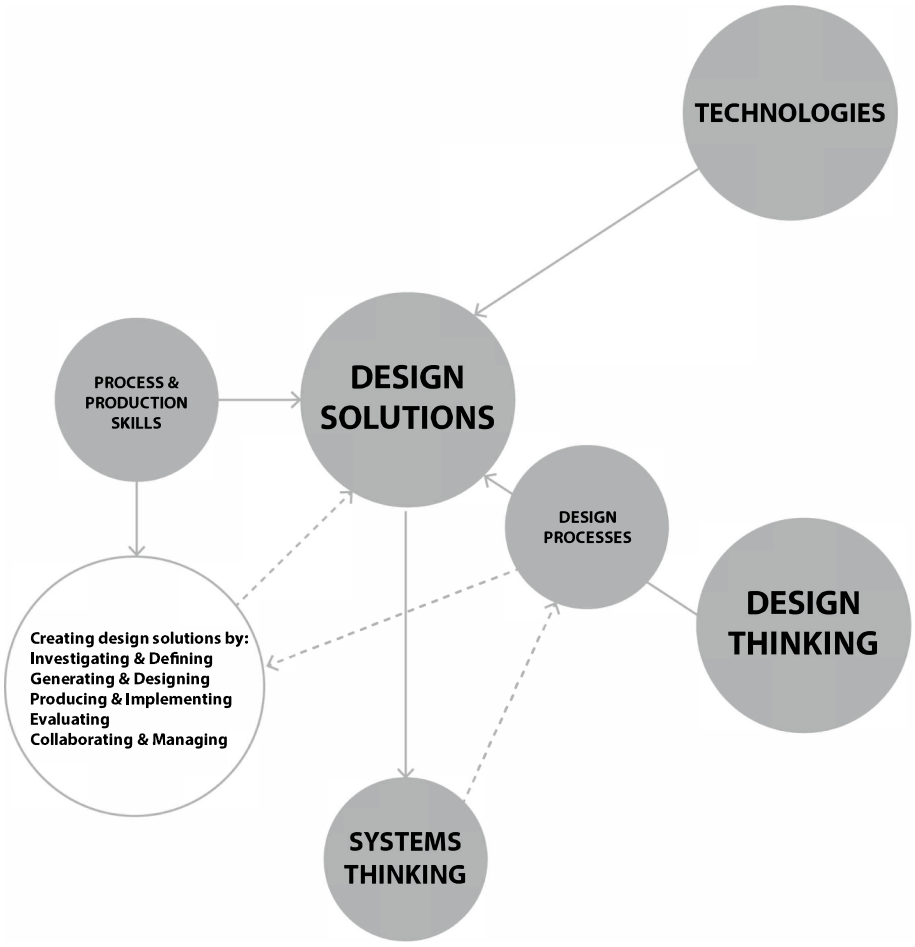

Fig. 2 Section of Design and Technology concept map

Curriculum 2016, p. 5). The design process is coupled with knowledge and understanding of technologies, to lead to design solutions. The curriculum states the design process also assists students to understand "design needs and opportunities" and generate creative and innovative ideas that meet design criteria (Australian Curriculum 2016, p. 5).

As well as design thinking, the Design and Technologies curriculum links 'processes and production skills' to design solutions and design processes. The 'processes and production skills' show that designing is used across both subjects to create solutions in different contexts. 'Processes and productions skills' are listed as five phases and are defined as:

- Investigating and defining;
- Generating and designing;
- Producing and implementing;
- Evaluating; and
- Collaborating and managing (Australian Curriculum 2016, p. 8–9).

The idea that 'processes and production skills' are used to create solutions is common across both the Design and Technologies and Digital Technologies subjects (Australian Curriculum 2016, pp. 8–9).

Our concept mapping confirmed that these curriculum documents establish a connection between 'process and production skills' and 'design processes'. These concepts involve similar key phases: investigating, generating, producing and evaluating (Australian Curriculum 2016, p. 5 and p. 8–9). Key concepts 'design thinking', 'design processes' and 'process and production skills' are linked in the curriculum to produce 'design solutions'. These links can be identified in the following extract:

> consideration of economic, environmental and social impacts that result from designed solutions are core to design thinking, design processes and Design and Technologies (Australian Curriculum 2016, p. 5).

Additionally, the curriculum document emphasised design solutions as a central concept linked to technologies. For example, "students use design thinking and technologies to generate and produce designed solutions" (Australian Curriculum 2016, p. 4) and students "engage confidently with and responsibly select and manipulate appropriate technologies—materials, data, systems, components, tools and equipment—when designing and creating solutions" (Australian Curriculum 2016, p.4).

Figure 2 above depicts a section of the mapping showing key design related concepts and how they fit together. The grey circles represent important and frequently linked concepts in the curriculum and white background circles break down the concept further. Lines demonstrate a clear connection between each concept in the text and dashed lines represent an implied link. For example, 'design solutions' are linked to 'systems thinking'. The intention of systems thinking is to help students work with complexity and risk and to understand design needs. The curriculum requires students to apply knowledge and practical skills of technologies to develop innovative solutions to "complex challenges" (Australian Curriculum 2016, p. 4). Systems thinking thus affects the success of design solutions, showing a clear link between the two concepts.

The success of design solutions includes the generation of ideas and decisions made within the 'design process' which requires an understanding of systems (Australian Curriculum 2016, p. 5). There is an implied connection between students using 'systems thinking' in 'design processes' however this is not explicitly stated in the text. The location and

presentation of 'systems thinking' within the text builds a particular understanding of the term in relation to design.

While design is present across both subjects within the Technologies curriculum documents, the mapping of the documents rationale has revealed that representations of design are more prevalent in the Design and Technologies subject area. Concept mapping of the Technologies overview revealed a limited representation of design within Digital Technologies, while demonstrating the connection between the two subjects, through 'systems' and 'design thinking' and the 'processes and production skills' strand. The concept map illustrates how key ways of thinking and knowing are connected across the curriculum through the two subjects, Design and Technologies and Digital Technologies. This analysis has illustrated that while present across both subjects, 'design' is predominantly represented in Design and Technologies however, key terms and concepts related to design identified as 'technologies', 'solutions', 'systems', 'processes', production' and 'skills' are present across both subjects.

Identification of key categories

Building on the concept mapping, which identified key terms and concepts associated with 'design' in the overview section of the curriculum document, a word frequency search for the term 'design' was carried out across the entire document to identify further categories related to design within the text as the concept mapping only analysed the first 9 pages of the document. This identification of categories was systematically carried out across the document's 133 pages. The results of this secondary frequency analysis, recorded in Table 1 (below), supported the development of a 'collection' of categories commonly used in the curriculum document in relation to 'design'. An example of an extract investigating categories is shown below.

> Design and Technologies, in which students use design thinking and technologies to generate and produce designed solutions for authentic needs and opportunities
>
> **Extract 1** (Australian Curriculum 2016, p. 4)

This extract is drawn from the second and third lines of the curriculum document. The extract highlighted three key categories that interact with 'design' in the text, namely; 'technologies', 'produce' and 'solutions'. The analysis revealed that certain categories and predicates were associated with 'design' in this document more frequently than others, which was also illustrated through the mapping analysis. The overall results of the category word frequency results are broadly discussed below in Table 1.

The initial word frequency search demonstrated that 'technologies', cited 389 times is the most mentioned word of terms related to 'design' in the Technologies curriculum document. The next most repeated words derived from the data were 'solutions' (n = 269), 'systems' (n = 247) followed by 'processes' (n = 156) and 'production' (n = 123). The search highlighted that the term 'solutions' was featured more with more than twice the frequency of the term 'create' (n = 96) and five times the frequency of the term 'making' (n = 54). 'Create', 'creativity', 'making' and 'drawing' aren't significantly emphasised within the curriculum compared to 'solutions', 'processes' and 'production'.

The frequency of the terms 'problem' (n = 74), 'complex' (n = 17), and 'solve' (n = 16) are also relevant, as design and designing are often represented in this curriculum as being related to solving problems in different ways. 'Sustainability' (n = 80), 'future' (n = 47) and

Table 1 Word frequency results in Technologies

Category	Frequency
Technologies	389
Design	336
Solutions	269
Systems	247
Processes	156
Designed	152
Production	123
Create	96
Skills	95
Product	89
Sustainability	80
Problem	74
Designing	63
Making	54
Future	44
Drawing	40
Complex	17
Solve	16
Designs	16
Aesthetic	12
Design Thinking	12
Enterprise	12
Innovation	12
Designers	11
Draw	9

'innovation' (n = 12) are referenced regularly in the curriculum in relation to design, for example "designed solutions for sustainable futures" (Australian Curriculum 2016, p. 52) and "create innovative designed solutions" (Australian Curriculum 2016, p. 54) so were selected for analysis comparison.

Examining the categories linked to 'design' in the curriculum

The identification of key categories from the Technologies curriculum demonstrates that 'design' has a clear connection to 'technologies', 'processes', 'production', 'problems', 'create' and 'solutions' in the text. The analyses of such categories revealed that design has a strong connection to and is situated within a technologies-dominant context in the curriculum. Design is discursively positioned as an approach to producing 'solutions' to critical problems through the use of technologies. This position resonates with Christensen et al. (2019) finding that identified a 'technology-focus bias in the design process' in their investigation of middle school students' design literacy acquisition. The analysis of the two subjects within the Technologies curriculum suggests that the word 'technologies' is used to replace a number of representations of 'design' in the curriculum.

Within the curriculum document, the primary representation of the category of 'technologies' describes a strong relationship with the act of 'designing' and creating 'design solutions'. The emphasis within the text appears to be on the relationship between technologies and 'design', 'designing' and the 'design process' being integrated in a complementary way to "create designed solutions" (Australian Curriculum 2016). For example:

> investigating and selecting from a broad range of technologies – materials, systems, components, tools and equipment- when designing for a range of technologies contexts (Australian Curriculum 2016, p. 81)
> experimenting with traditional and contemporary technologies when developing designs (Australian Curriculum 2016, p. 82)
> re-imagining designs to feature emerging technologies" (Australian Curriculum 2016, p. 90).

Where design is connected to 'technologies' in the text, the emphasis of the curriculum is placed on 'technologies' not designing, the design process or methods required to apply those technologies to solve problems. In the examples above, design processes appear to be secondary to "investigating", "experimenting with" and "featuring" new technologies and, as such, the space that design occupies is marginalised. This focus is suggestive of the positioning of 'Design and Technologies' within the broader classification of the Technologies KLA. As previously stated, the inclusion of Design and Technologies and Digital Technologies as a single learning area under the Technologies curriculum has been viewed as problematic since its conception (Banks and Williams 2013). Prioritising technologies over design shifts the thinking in the curriculum, from a focus on design process to a focus on the technologies used to create and created by such designs.

A clear example of the positioning of technologies over design is seen by 'technologies specialisations'. Within the curriculum technologies specialisations are defined as "areas of specialisation that typically involve extensive use of technologies (for example, architecture, electronics, graphics technologies, fashion" (Australian Curriculum 2016, p. 47). Within professional practice, architecture, graphic design and fashion are design disciplines or design specialisations. The curriculum has not only replaced 'design' with 'technologies' in 'graphic technologies' but it has developed a discourse that repositions design professions as technologies professions, impacting not only how teachers interpret and represent design disciplines but also potential student career aspirations.

Further to this, 'technologies processes' are used as a substitute term for 'design processes' that "allow the creation of a solution" (Australian Curriculum 2016, p. 46). In the Digital Technologies curriculum document, for example, rather than referring to 'design processes' and 'design solutions', references are made to 'technologies processes' and 'technologies solutions'. For example, 'design process' is defined within the curriculum as,

> A process that typically involves investigating and designing; producing and implementing; evaluating; and collaborating and managing to create a designed solution that considers social, cultural and environmental factors. In Design and Technologies, technologies processes include design processes and production processes (Australian Curriculum 2016, p. 19).

Comparatively, 'technologies processes' are defined as "Processes that allow the creation of a solution for an audience (end user, client or consumer)… The processes involve: investigating and designing; producing and implementing; evaluating; and collaborating and managing (design processes) and technologies specific production processes" (Australian Curriculum 2016, p. 46). Within this discourse, design processes are embedded within

technologies processes and not positioned as processes in their own right. Students design within a technologies context and use and develop technologies through the design process. Creating a strong connection between 'design' and 'technologies' develops an understanding that design will occur within a technologies (digital) context.

Additionally, the 'design process' is discursively positioned as a secondary tool to understanding 'technologies'. The curriculum states, technologies "are used to create solutions for identified needs and opportunities" (Australian Curriculum 2016, p. 46). Technologies are represented as the tools used to solve problems as well as a process that allows for the creation of solutions and as a context in which these solutions are developed (Australian Curriculum 2016, p. 46). Technologies appear to be prioritised in the curriculum at the expense of 'design'.

Creating designed and digital 'solutions'

The analysis revealed inconsistencies in the definitions of terms and processes within the curriculum. The same processes are used to reach different types of solutions across different contexts. 'Digital' solutions and 'design' solutions are defined differently but the curriculum states that students use the same 'processes and production skills' to achieve them. (Australian Curriculum 2016. p. 8–9) This discourse reveals a lack of clear distinction between the processes required for the two subjects. As such, there is a potential for teachers and students to confuse the processes and lack a clear understanding of the various solutions that they are working to create.

While the 'processes and production skills' steps to create designed and digital solutions are discursively positioned as being the same within the Technologies curriculum, the processes and production skills are defined differently in the Design and Technologies and Digital Technologies KLAs. In Design and Technologies, the "processes and production skills strand is based on the major aspects of design thinking, design processes and production processes" (Australian Curriculum 2016, p. 56). In Digital Technologies processes and production skills involves "using digital systems to create ideas and information, and to define, design and implement digital solutions, and evaluate these solutions and existing information systems against specified criteria" (Australian Curriculum 2016, p. 94). Nonetheless, the discursive representation of the 'processes and production skills' across the two distinct subject areas suggests a set of prescribed and identical components and steps. There is contradiction inherent within the document, whilst 'processes and production skills' are defined differently across the two KLAs, there is a repetition of steps within the process types to achieve both 'design solutions' and 'digital solutions'. This ambiguity holds the potential to create confusion about what the terms 'processes and production skills' mean, how they are different or similar and how they are to be implemented. For example, the 'design process' is defined in the same way as 'processes and production skills'. As identified earlier, these five phases are: (1) investigating and defining, (2) generating and designing, (3) producing and implementing, (4) evaluating and (5) collaborating and managing (Australian Curriculum 2016, pp. 8–9 and 19).

Additionally, 'designing' is defined as the five 'design process' steps with the term 'designing' removed from second step of the process (Australian Curriculum 2016, p. 19). 'Technologies processes' encompass 'design processes' and 'design processes' encompasses 'designing'. The terms being defined are not only a part of the definition, they are the same definition, creating a circular logic within these key terms and a lack of clarity. Such a circular logic holds the potential to impact on teachers' understanding of processes

that students require in the two learning areas. These 'process' terms require greater explanation to differentiate them and distinguish the difference between a 'technologies' process, a 'production' process and a 'design' process (Donnelly and Wiltshire 2014). The lack of a clear distinction of these terms constructs a narrow understanding of design thinking and design processes, which limits teachers' potential understanding of key design concepts and their capacity to enact the curriculum.

Variations of 'design'

The similar but contradictory nature of design concepts within Technologies suggests that greater differentiation between the terms in the text and their contexts is required and raises questions about the multiple representations of design in the curriculum. If 'design processes', 'designing' and 'process and production skills' are defined in the same ways, or largely the same ways within the text, why are they referred to by different terms across the two subject areas? If there are differences between the terms, as the literature suggests, why are they defined in the same way? Perhaps this has been done in an attempt to simplify these terms but has paradoxically made them more confusing. Additionally, what do these confusing and circular definitions mean for teachers interpreting an enactment of the curriculum and what impact does that have on students' understanding of design concepts? The representation of design and design thinking in the curriculum highlights how these concepts are valued and arguably demonstrates that they have been defined in the same unified way to enable the curriculum to align with STEM policy agendas.

Although they are often and problematically defined as the same (as seen within the Australian Curriculum), 'design' and 'design process' are distinct and different (Love 2002). Adopting Love's (2002) definition of 'design process' as "any process or activity that includes one or more acts of designing with other associated activities" (p. 358) provides clarity between the two concepts in the curriculum. Additionally, Love's definition demonstrates that design thinking is used within the design process, by designers when they solve problems.

Analysing 'design' in context within the text, highlighted the creative process of design is not strongly represented across the Technologies curriculum. The skills, values and knowledge that are expected to be developed through learning in Technologies, impact how the curriculum positions and represents concepts, particularly design (Wells 2013). The inconsistencies and lack of clarity around design within the Technologies document have the potential to undermine its aim of fostering the twenty-first century skills and innovative capability design can build within students. Further, the rich experiences found in design education and the value that they can potentially provide for students may to some degree become lost.

Conclusion

Education policy recognises the need to develop complex problem-solving skills, creativity and collaboration capabilities that are essential to innovation (ACARA 2012b; ACOLA 2016; Australian Government 2015). It is argued within the research literature that design is integral to developing these skills (Howard 2008, 2016; Goldman and Kabayadondo 2017; Keane and Keane 2016). The Design Council (2018) argues, "along with Art, design methods, tools and approaches should be incorporated into STEM subjects to boost the

skills required in the future economy" (p. 11). Ensuring design concepts and the representations of design professions across the curriculum are resolved, consistent and integrated has never been more crucial.

Design and technology are intrinsically linked, with design being used to develop new and innovative technologies (Howard 2008; Katz 2015) and, conversely, technologies providing different affordances for design processes and products. As previously stated, Design and Technology grew out of the amalgamation of practical craft-based subjects, resulting in the creation of Design and Technology as a "curricula entity" (Bell et al. 2017, p. 2). The subject focused on the development of practical and technical skills (Martin and Owen-Jackson 2013). The analysis presented in this study revealed that concepts of design are frequently represented within the Technologies curriculum. These representations extend a focus on technology as being integral to design processes. Staying true to the subject's origins, the Technologies curriculum has retained a strong focus on production, solutions and skills-based processes and materials but has repositioned this focus to include digital technologies and virtual design process spaces. The amalgamation of design across Design and Technologies and Digital Technologies is a new curriculum context for Technologies education in Australia (Banks and Williams 2013; Fleer 2018). The research raises the question of whether this repositioning of Design and Technologies will mean that design is going to be increasingly viewed in relation to and specifically in terms of its virtual technology futures. Furthermore, will the preference and move towards digital technologies reduce the potential impact of the concept of design in terms of creative or practically-based pursuits?

As Wells (2013) argues, the development of a new technologies curriculum provides an opportunity to "explore and implement more accurate interpretations of design thinking and improve the value of students' design knowledge and experience" (p. 631). However, the new Australian curriculum area of 'Technologies' ambiguously offers multiple meanings of design while not giving the concept any substantial or clear definition that would enable teachers to support young people to understand and learn about design in context. In addition, the repetition and complexity of definitions of design create confusion and enable multiple interpretations potentially leading to the initial intention of the curriculum being lost. This is a problem if design is to reach its full potential in curriculum to assist in the development of building creative, curious and imaginative thinkers.

The current discursive representations of design within the curriculum have the potential to develop particular understandings of and ways of knowing about design for an entire generation of students. The dominant positioning of design as a process used to create both 'design solutions' and 'digital solutions' obscures the ways of knowing inherent in design education. Additionally, the 'designer' is underplayed across the curriculum, their material understandings and more traditional material ways of thinking and knowing are being pushed out of the curriculum and replaced with 'technologies'. Fleer (2018) describes them as "high technologies" (the most advanced technologies available) or virtual thinking and designing spaces (p. 69). The tools or processes of design and the dominance of virtual designing with created tools have taken precedence over the design and the designer. The tightened reference to design may raise questions about priorities and political agendas in the curriculum.

The findings of this article present many possibilities for further inquiry. The purpose of this study was to understand where representations of design occurred throughout the Australian Curriculum: Technologies and to consider the effects of such representations. Curriculum content, however, only attempts to mandate what is intended to happen in the classroom. Findings from this paper demonstrate a lack of consistent representation

of design across the curriculum documents and the positioning of design and design processes within the field of Technologies. The focus of this study provides scope for further inquiry to investigate teachers' understanding of design in the Australian Curriculum and how the curriculum is enacted. Investigating how design is present in the enacted curriculum by interviewing teachers on their background, knowledge and understanding of design and their interpretation and enactment of the curriculum would build on and complement this study. Additionally, classroom observations and focus groups with students would investigate students understanding of design across the curriculum. Further to this, as the Australian Curriculum is interpreted by each State and Territory, a study could be conducted examining how these understandings of the representation of design vary across the country.

This article has provided the foundation to explore representations of design within the enacted Technologies curriculum across F-10 educational contexts in Australia. If the intended representation of design in the curriculum is not evolved, developed or clarified it will have implications for students and teachers across Australia.

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