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# Transforming Pre-Service Teachers' Beliefs and Understandings about Design and Technologies

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*Abstract: Design and Technologies challenges students to think differently: to think critically and creatively. Yet, how, when and why students are exposed to Design and Technologies curriculum in school classrooms is at the prerogative of their teacher. For this reason, it is imperative that pre-service teachers are inspired by and engaged through relevant, rigorous and responsive courses throughout their undergraduate teaching program. Situated within the Bachelor of Education (Primary and Middle) degree at the University of South Australia, Australia, this study captures pre-service teachers' emerging beliefs, attitudes and understandings of Design and Technologies. Drawing on the comparative responses of pre-service teachers collected at the commencement and conclusion of an undergraduate Design and Technologies course, this paper highlights how immersion in a curriculum area can transform pre-service teachers' theoretical, conceptual and practical understandings and how this may influence how, when and why they incorporate the learning area in their subsequent teaching experiences.*

## Introduction

Pre-service teaching experiences are influential in developing an educator's subsequent beliefs, pedagogy and practice. How pre-service teachers approach and engage with learning experiences shapes their perceptions of particular learning areas and informs their understanding of curriculum. Even before pre-service teachers commence their undergraduate teacher education programs, they often possess preconceived beliefs about teaching and learning based on their own schooling experiences. It is not unexpected, therefore, that pre-service teachers often specialise in learning areas which they enjoyed whilst students themselves.

Primary and middle school teachers are often considered 'generalists' with a specialisation: that is, they are expected to teach across the curriculum, despite possessing deeper understanding of one or two particular learning areas. Therefore, pre-service teachers often enrol in undergraduate teaching courses with little (or misguided) understanding of what each learning area involves, or with preconceptions based on their own experiences as school students. Higher education courses must therefore endeavour to challenge existing beliefs and meaningfully scaffold theoretical, conceptual and practical understandings of each learning area to reflect contemporary curriculum frameworks.

Traditional understandings of Design and Technologies are often associated with subjects such as Home Economics (food and textiles) or Technical Studies (for example, wood and metal work). However, the learning area is much broader than this: Design and Technologies is an education for an increasingly diverse world, where change is rapid and incessant. Students must therefore be equipped with the skills, knowledge and dispositions to

engage in a rapidly changing context, where they question, critique and challenge products, processes and systems to become informed, critical and discerning choosers and users of technology.

This paper begins with a description of Design and Technologies and how it scaffolds learners to be critical and creative thinkers. This will be followed with a discussion of research pertaining to pre-service teacher beliefs, to highlight how immersion in experience can shape how they approach the processes of teaching and learning. Following, data collected from 164 first year Bachelor of Education (primary and middle) pre-service teachers will be reported upon to portray how engagement in a rigorous, relevant and responsive twelve week Design and Technologies curriculum can challenge, broaden, foster and inspire pre-service teachers' theoretical, conceptual and practical understanding of the learning area. This paper concludes with a discussion of how contemporary higher education Design and Technologies can develop the capacities of pre-service teachers to be informed, innovative, engaging and inspiring educators.

## Design, Technology and the Australian Curriculum

Technology is everywhere in our lives. How and why we create and live with technologies is no longer something we can accept unquestioningly. Technologies can present solutions, but they can also be problematic. Our relationship with technology is complex and, because of this, we need an education about, for and in technologies. This means more than just learning how to use technologies; it is about asking questions and finding new ways to think about the technological world. A quality Design and Technologies education needs teachers who can help their students to critically engage with their world.

An education in Design and Technologies aims to create technologically literate learners by offering a blend of knowledge, skills, strategies and dispositions to develop students' identities as individuals, and to assist them to design shared, sustainable futures. As students develop their capacities to critique the technological and designed worlds around them, they learn to question, challenge, detect and deconstruct, and become empowered to effect change. Technologies, in their development and use, are influenced by—and can play an important role in—transforming, restoring and sustaining our societies and our natural, managed, constructed and digital environments. In this paper it is argued that technologies do not exist in isolation, but are situated amidst social, economic, environmental, cultural and political agendas. For this reason, the Australian Technologies curriculum is instrumental to students, both now, and in the future. Thus, it is contended, the learning area supports theoretical, conceptual and practical understanding of traditional, contemporary and emerging technologies (ACARA, 2012).

Central to Design and Technologies is the capacity to think critically and creatively in order to make informed decisions regarding the design, development and use of technological systems, processes and products (Best, MacGregor & Price, 2017). As students solve design-based problems, they design, create, analyse and evaluate outcomes; skills referred to as higher order thinking. The ability to think critically and creatively empowers learners with new ideas and the ability to consider a diversity of perspectives. In doing so, Design and Technologies provides valuable opportunities to devise and develop responses to perceived challenges and problems. That is, the learning area affords opportunities for students to critically consider, challenge and unpack existing understandings associated with the terms 'design' and 'technology'.

Design is integral to the creation of new (and renewed) technologies, processes and systems. Brinkkemper (1996) emphasises a key component of design is considering and

responding to the aesthetic, functional, economical and socio-political aspects of a design object and design process. Designing can be complex in that it draws on established and new values, skills, techniques, knowledge and thinking to achieve particular goals. As this paper will argue, design should be considered as a problem-solving process. Problem solving, as widely acknowledged, is a lifelong skill, one that extends well beyond the classroom walls.

Selwyn (2017, p.7) defines technology as 'the process by which humans modify nature to meet their needs and wants'. Sharing a similar view, Rennie and Jarvis (1994) suggest that technology emerges from the purposeful application of knowledge, experience and resources to create products, processes and systems that meet perceived needs. That is, technological products, processes and systems are responses to a need to make something, to improve something, or to solve a problem. This involves applying scientific knowledge, as well as skills such as thinking, designing and using materials with intent for environmental sustainability and product/process longevity (Rennie & Jarvis 1994). Many technologies capitalise on the use of previous research and experiences and, in this sense, many technologies are evolutionary, with past, present and future aspects.

Therefore, it is becoming increasingly important that we examine not only our existing technologies, but also the intentions behind the design of new ones. It is no longer appropriate to passively accept designed and technological products. With this view, it is argued that pre-service teachers need the skills to question, critique and challenge existing ways of thinking, doing and knowing. For, if pre-service teachers develop these critical thinking skills, they are more likely to provide opportunities for their subsequent learners to develop similar discerning dispositions: that is, learners must be afforded opportunity and support to challenge, critique and question the world in which they live. As Selwyn (2017, p. 2) asserts, 'anyone interested in education has a growing need to be mindful of the complex relationships that are developing between education and technology'.

Although it has been suggested that Australia needs enterprising individuals who can make discerning decisions about the development and use of technologies, it likewise needs educators who can foster such capacities within learners. There is a growing need for people who can independently and collaboratively develop innovative solutions to complex problems and contribute to sustainable patterns of living (ACARA, 2012). As premised within the newly developed and adopted Australian Curriculum framework, technologies enrich and impact on the lives of people and societies globally (ACARA, 2012). The learning area of Technologies therefore comprises two distinct yet related subjects, namely Design and Technologies, and Digital Technologies (ACARA, 2012). Central to Design and Technologies, students 'use design thinking and technologies to generate and produce designed solutions for authentic needs and opportunities' whereas in Digital Technologies, students draw on 'computational thinking and information systems to define, design and implement digital solutions' (ACARA, 2012).

Within Design and Technologies, a series of Processes and Production Skills (investigate, design, produce, evaluate, collaborate and manage) aim to provide learners with the knowledge, skills and understanding to design, produce and evaluate designed solutions (ACARA, 2012).While there is a strong relationship between investigating, designing, producing, evaluating, collaborating and managing (ACARA, 2012), these processes are rarely linear. Through investigation, designs develop and new thinking is generated. This evokes further critical thinking and investigating. Through the production process, problems or unexpected events often require problem solving or conceptual redesign. Following the producing phase, designers often refer back to the original intent or design brief for which the artefact was designed. Hence, each of the Processes and Production Skills are interwoven through product (re)design and (re)development and are not in considered in isolation.

Therefore, in Design and Technologies, school students shouldn't simply make something, but they should be afforded opportunities to think about what they produce, how their creation has an impact on resources, and the implications of their use (Best, MacGregor & Price, 2017). Educators must promote critical thinking and reflection in learners, requiring them to question and to think about what technological experiences, understanding and skills they need in order to work in this way. However, the ways in which learners understand and interact with technological products, processes and systems is informed by the practices of their teacher; which are often shaped through pre-service teacher education. It is for this reason that undergraduate teaching courses must foster the dispositions and capacity for pre-service teachers to truly understand and effectively teach Design and Technologies.

**Pre-service Teacher Beliefs**

Investigating the changing beliefs of pre-service teachers is not new. In fact, numerous researchers have explored the influence of undergraduate teacher education courses on pre-service teacher beliefs, understandings and dispositions within particular learning areas, as well as broader pedagogy and philosophy. Emerging from his well-regarded research on teacher beliefs, Pajares (1992, p. 307) has stated, 'beliefs are the best indicators of the decisions individuals make throughout their lives'. He furthermore notes the connection between teachers' beliefs and their subsequent planning, pedagogy and practice. In their critique of epistemological beliefs in teacher education, Brownlee et al. (2001, p. 262) has argued that teacher education courses must provide opportunities to support pre-service teachers to 'develop sophisticated beliefs about knowing'.

Following Pajares' (1992, p. 321) rationale that a 'change in beliefs follows, rather than precedes, change in behaviour', it is argued here that, through the practical nature of Design and Technologies, there is scope for subsequent change in pre-service teachers' beliefs. This follows the logic of Albion and Ertmer (2002, p. 35) who state, 'If beliefs are formed and developed through personal experience then it seems logical that changes in beliefs should also be effected through experience'. However, there is limited empirical evidence to document how teacher education influences pre-service teachers' values and beliefs (Tatto, 1998).

Research has consistently suggested that teachers' beliefs strongly influence their approaches to teaching and learning (Debreli, 2012), as well as how they plan, select resources, and how they interact with students (Clark & Peterson, 1986). Teacher practices are often guided by their personal beliefs and values in the sense that they prioritise leaning experiences and approaches based on what they perceive as important (Debreli, 2012). Such beliefs shape conceptions of a teacher's professional role and, thus, their teaching pedagogy and practice (Tatto, 1998). For example, as Debreli (2012, p. 368) notes in relation to language teaching, 'if a teacher believes that the languages could be best learnt by investing more time in teaching grammar, he/she is likely to invest more time in teaching grammar in his/her classroom'.

Findings from studies investigating changes in pre-service teachers' beliefs have reported mixed results. Weinstein (1989), for example, has argued that while pre-service teacher education courses may influence practice, this does not necessarily result in changes to underlying beliefs (Prawat, 1992). Tatto (1998, p. 66) furthers this notion, suggesting that changes in practices and beliefs which occur as a result of teacher training programs 'do not necessarily generalise across the teaching of different subject matters'. Therefore, while a particular pre-service teaching course may bear some influence over practices or beliefs, such changes may relate to a particular learning area, as opposed to more universal changes to an

individual's philosophy or pedagogy. It has further been contended that the personal schooling experiences of pre-service teachers are more influential than undergraduate university courses in shaping beliefs regarding teaching and learning (Lortie, 1975).

Almost forty years following Lortie's (1975) finding, Debreli (2012) explored Cypriot pre-service teachers' beliefs regarding teaching and learning English as a foreign language over a nine month period. Implementing semi-structured interviews with three final year undergraduates, he reported no observable changes in the first term of a course. In fact, he found pre-service teachers' initial beliefs which aligned with the content and philosophy of the course were reinforced and strengthened. Hence, Debreli (2012) reported that pre-service teachers' beliefs regarding teaching and learning English as a foreign language were influenced through their own schooling experiences and interactions with teachers.

In contrast, Sharma and Sokal's (2015) comparative Australian and Canadian research, which investigated the impact of two university courses on pre-service teachers' attitudes, concerns and teaching efficacy to teach in inclusive classroom settings, found that following a university course focussing on inclusive education, Australian pre-service teachers' attitudes and confidence towards inclusion improved, with concerns regarding diversity reducing. While their research findings regarding concerns and teaching efficacy were similar for the Canadian pre-service teachers, this cohort reported greater apprehension about teaching within inclusive classrooms. This study alone suggests the way in which university courses are designed, developed and delivered influence how pre-service teachers' beliefs, attitudes and dispositions are shaped.

Tatto's (1998) quantitative study investigating pre-service teachers' perceptions of the purpose of education, and teachers' professional role, beliefs and practices, found teacher education courses influence pre-service teacher views. However, Tatto (1998, p. 76) argues that programs which are 'internally coherent' regarding shared understandings and norms often result in graduates whose beliefs mirror their faculty. From this perspective, beliefs are more susceptible to change when there is consensus across courses and throughout an undergraduate program. Although such coherence can work to scaffold pre-service teachers as reflective practitioners and critical thinkers (Tatto, 1998), it does not necessarily facilitate a change in beliefs regarding particular learning areas. Such a view parallels Paolucci's (2015) research regarding the nature of mathematical beliefs of pre-service teachers, where participants failed to recognise the capacity of the learning area to evoke critical analysis and creative thinking. Yet critical and creative thinking is central to innovative and responsive teaching and learning, particularly in the learning area of Design and Technologies. In support, Florian and Spratt (2013) have argued that all teacher education programs must prepare prospective teachers to be reflective practitioners who have the capacity and ability to respond to the unique needs of learners.

Although numerous studies have investigated the changing beliefs of pre-service teachers across different curriculum areas, there is little, if any, exploration within the field of Design and Technologies. Much research within Design and Technologies has focussed on the incorporation of technology in to educational settings, rather than the emerging understandings and beliefs of those involved. The limited research pertaining to pre-service teacher education and Design and Technologies has primarily focussed on the implementation of digital technologies or information and communications technologies within classrooms (see, for example, Albion & Ertmer, 2002; Goos, 2010; Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2012), rather than the emerging beliefs and understandings of those teaching within the learning area. In doing so, existing research has not fully explored the powerful influence of physically engaging learners in hands-on, real world experiences.

Underpinning this study is the design, development and delivery of course content which addresses theoretical, conceptual and practical understandings of Design and Technologies. Such vision aligns with recent research which has argued for teacher education courses to advance pre-service teachers' understandings of 'good' pedagogical practices, technical capability and conceptual links between and across concepts (Koehler & Mishra, 2009). The Design and Technologies course from which this research is based adopted a constructivist orientation where pre-service teachers were encouraged to 'engage in dialogue, reflection, and inquiry' (Tatto, 1998, p. 66) in order to facilitate change in thinking. It is contended that exposure, engagement and experience within undergraduate teacher education courses can serve to shape subsequent beliefs regarding particular learning areas.

## The Study

This paper focuses on a Design and Technologies course provided through the School of Education at the University of South Australia. The four-year Bachelor of Education (primary and middle) degree prepares pre-service teachers for generalist teaching from reception to Year 10, in addition to specialising in two learning areas up to Year 10. Within the first year of their degree, pre-service teachers complete a twelve-week Design and Technologies course which provides theoretical, practical and conceptual knowledge, experiences and skills required to engage learners in a rapidly changing world.

The undergraduate course comprised three modules, each being four weeks in duration, which closely aligned with the Australian Curriculum Technologies Contexts and addressed the related strands of Processes and Production Skills and Knowledge and Understanding (ACARA, 2012), which in brief, aim to provide learners with the knowledge, skills and understanding to design, produce and evaluate designed solutions (ACARA, 2012). Module 1, *Technologies and society: Understanding our technological world*, introduced pre-service teachers to holistic conceptualisations of design and technology and challenged understanding of the terms 'design' and 'technology' in relation to historical, contemporary and emerging social and cultural perspectives. Module 2. *Technologies contexts: An introduction to engineering principles and systems*, was a fundamentally practical module in which pre-service teachers developed their conceptual and practical understanding of systems including electrical, pneumatic/hydraulic and cams. The third module, *Technologies contexts: Food and fibre production* explored sustainable agribusiness and furthered understanding of food and fibre production within both Australian and international contexts. Each module comprised of four developmental topics which were covered in twelve, weekly two-hour on-campus workshops. Workshops were primarily practical in nature, facilitated by a tutor who taught the theoretical and conceptual content to scaffold leaners' practical hands-on experience. Learners engaged with weekly tasks on a particular topic, with much of their learning co-constructed in small groups. Additional resources and background reading was available to learners through the course website and interactive learning forums.

Complete data sets were collected from 164 first year pre-service teachers who were enrolled in the Design and Technologies course. Participants were aged 17 – 54 years with females representing 73 per cent of respondents. In total, 148 participants had completed high school the year prior to data collection. Data were collected through two qualitative surveys, designed to capture pre-service teachers' attitudes, beliefs and perceptions at the commencement and conclusion of the course. The surveys were administered in print format during university workshops, with each comprising five key questions. Participants were asked to avoid providing any identifying information in order to preserve their anonymity. The commencement survey, administered in the first week of the course, was designed to

capture pre-service teachers' initial conceptualisations of key terms such as 'design' and 'technology', as well as elicit prior experiences of Design and Technologies. Pre-service teachers were furthermore asked to record their expectations for the course and why they perceived it to be a compulsory core course. The completion survey, administered in week twelve, asked pre-service teachers about their post-course understandings of 'design' and 'technology' and their reflections on the course. The completion survey also asked pre-service teachers to comment on what they gained from the course (skills, knowledge and/or experience) and why they perceived the learning area to be a mandated aspect of the Australian Curriculum.

Analyses of survey data were primarily descriptive in nature and reflected pre- and post- course attitudes, beliefs and perceptions of Design and Technologies. Pre-service teachers' qualitative responses were content analysed (Cohen, Manion, & Morrison, 2007) with coding and interpretation based on thematically-derived categories. Broadly coded categories, as well as code names (Lodico, Spaulding, & Voegtle 2010), were developed from an iterative, inductive and systematic process of examining and exploring the data. To facilitate content analysis, data were thematically grouped as detailed throughout the findings and discussion section of this paper.

## Findings and Discussion

Pre-service teachers enter their undergraduate teacher education courses with existing beliefs and perceptions which are often based on prior schooling experiences. This study specifically asked participants about their previous learning experiences in Design and Technologies, their expectations of a Design and Technologies course, and their understandings of key terms relevant to this learning area. At the completion of the course, the participants were surveyed again to ascertain any changes in their understandings. The following sections focus first on the pre-service teachers' understandings of Design and Technologies prior to course commencement. Next, comparative insights, drawn from course commencement and completion data, are then presented. The section concludes with a discussion of how immersion in the learning area fostered increased understanding, valuing and confidence with Design and Technologies.

### Prior Experience with Design and Technologies

Data collected at the commencement of the course (see Table 1) indicated a significant proportion (n=103) of participants based their initial understanding of Design and Technologies solely on their own schooling experiences and particularly, recent experiences at high school. Typically, this school experience was in traditional 'Technical Studies' subjects, including woodwork, metal work, home economics and/or information processing, which were offered in Australian high schools before the introduction of the new Australian Curriculum (endorsed in 2015). A further 13 pre-service teachers connected employment (labouring, handling and processing food or shop assistant) or previous studies in higher education (visual arts and architecture) to developing their initial perceptions of the learning area. Notably, 37 respondents indicated they had daily 'real world' experiences with Design and Technologies through gardening, cooking, working with computers, repurposing furniture, designing posters or invitations, and using household technologies such as the telephone, television or kettle. Four pre-service teachers related their understanding of Design

and Technologies to broader conceptualisations including problem-solving and planning processes.

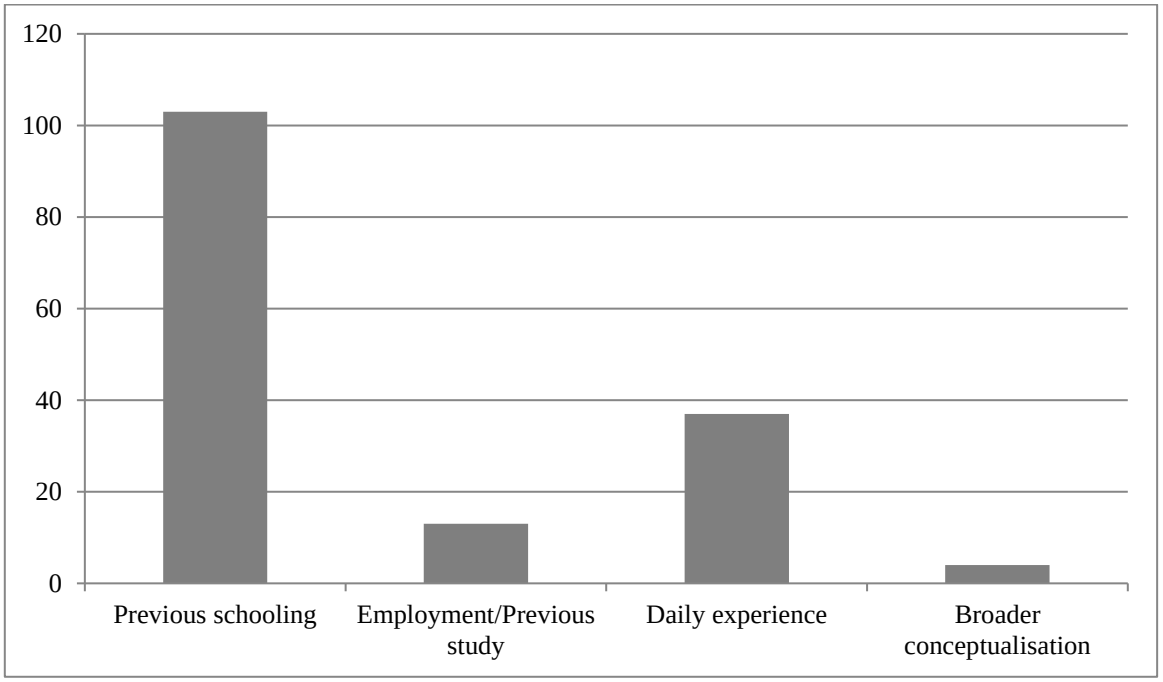


**Table 1: Prior experience with Design and Technologies**

**Shifting Understandings of 'Design'**

Initial understandings of the term 'design' were diverse, however several common themes emerged: design was conceptualised as both a verb and as a noun (see Table 2). Twenty-eight pre-service teachers perceived design as planning, problem-solving, creating, making for a specific outcome or based around constraints. Such views were presented in the form of a plan/sketch or blueprint of an intended solution to a problem (n=19), innovative or creative thinking (n=37) and ways of communicating an idea (n=13). Participants furthermore described design as a result of trial and error/risk-taking and problem-solving (n=14), an artefact that has a predicted outcome (n=1) or something that is created and adjusted in working towards an outcome (n=10), with 12 pre-service teachers linking such thinking to product functionality and practicality (rather than aesthetics). The notion of creating ideas and solutions to problems in order to produce new technologies with a specific purpose was also raised (n=10), as was critically analysing products to create something new or 'improve something old' (n=4). Sixteen respondents indicated that they did were not sure.

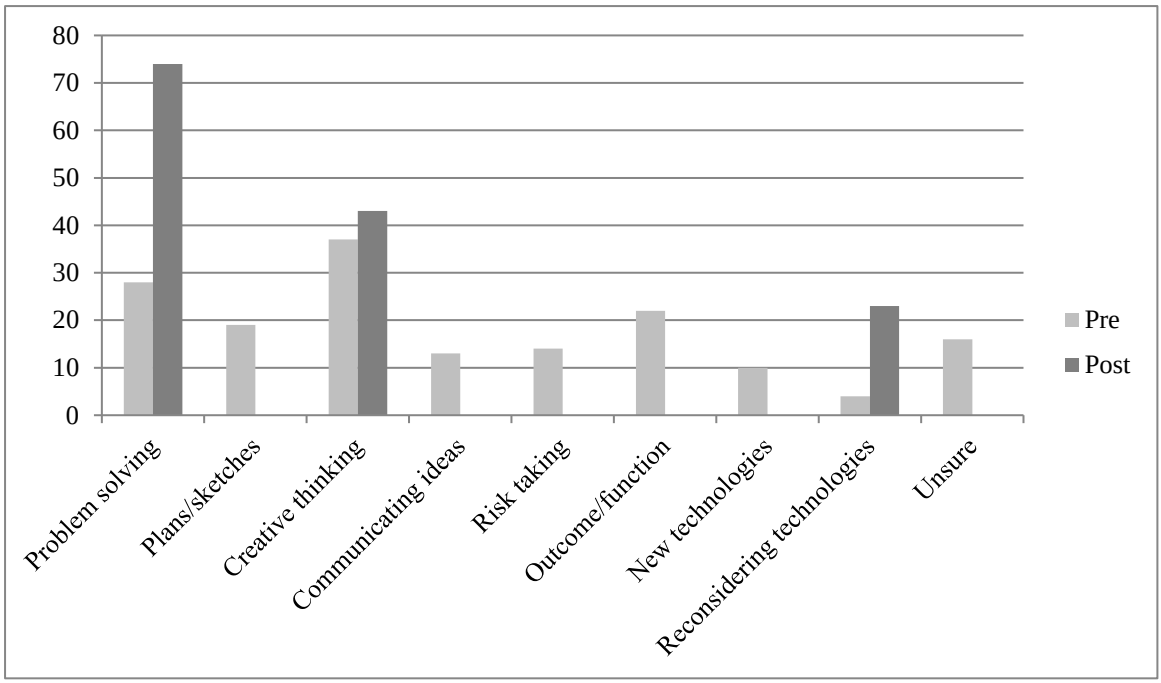


**Table 2: Understanding of 'design'**

The Australian Curriculum: Design and Technologies defines designing as 'a process that typically involves investigating and defining; generating; producing and implementing; evaluating; and collaborating and managing to create a designed solution'. Through exploring and linking learning tasks to the Australian Curriculum, completion data showed a significant number of participants (n=74) possessed a more developed understanding of 'design' in line with the definition offered in the Australian Curriculum (see Table 2). A further 43 pre-service teachers noted design involves creative, flexible, critical and reflective thinking to devise a solution to a perceived need or want. Given the practical, hands on nature of each of the weekly topics, scaffolded by conceptual and theoretical learning, participants demonstrated an enhanced understanding of design as an approach to (re)thinking about, (re)producing and (re)evaluating technological products, processes and systems (n=23).

#### Shifting Understandings of the term 'Technology'

Pre-service teachers' initial understandings of 'technology' fell in to several distinct categories (see Table 3). In total, 82 respondents understood technology to refer to an item or product, with computers, phones, cars, electronics and cameras being the most commonly cited objects. Given the emphasis on communicative technologies, nine pre-service teachers described technology as being a form of communication. A further 64 participants perceived technology to be 'modern', 'used every day', 'man-made' objects which are designed to 'make life easier', 'improve life' or 'make things more convenient', with a further five pre-service teachers stating 'advanced/constantly evolving', 'adapting something to make it better' and 'changing and improving', indicating the fluid nature of technological developments. A further 13 participants articulated that technology involves intent, that is, 'things that have been created for a particular purpose' or 'advances in a product with a purpose to benefit'.

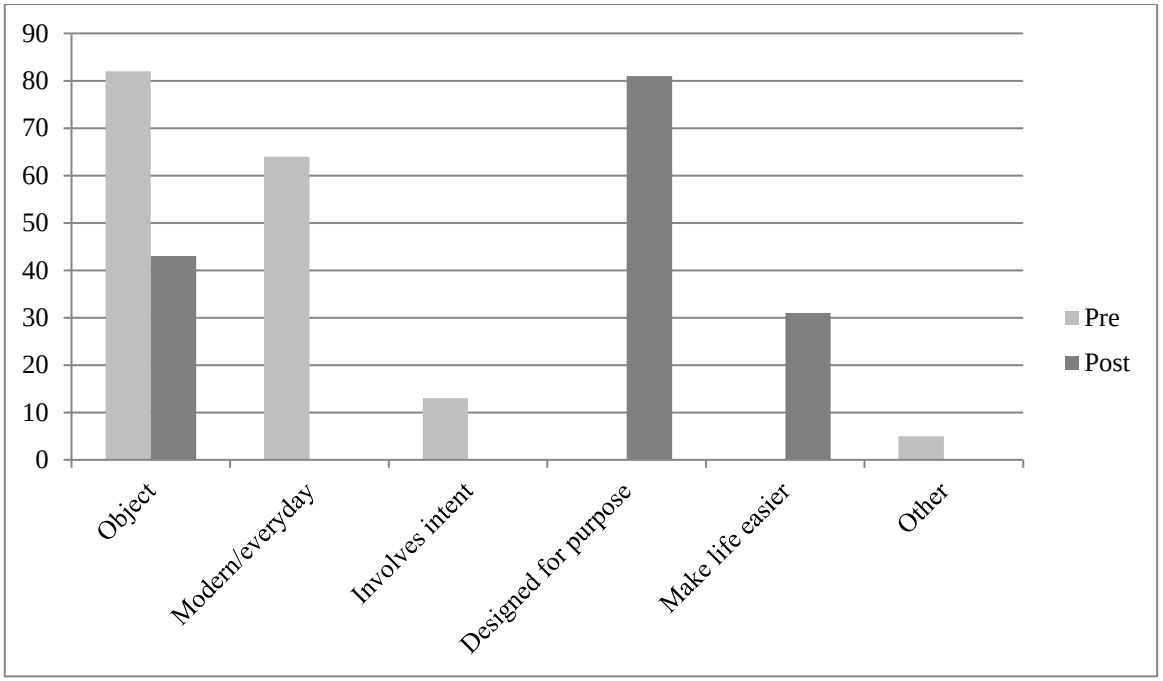


**Table 3: Understanding of 'technology'**

Notably different to earlier beliefs were pre-service teachers' understanding of the term 'technology' at course completion (see Table 3). Significantly, 81 participants indicated that technology was something that was designed for a perceived need/purpose or to solve a problem. That is, respondents did not cite common technological products as they did at the start of the course, but rather, they emphasised the notion that technology involves purpose. A further 43 pre-service teachers noted that technology was everything around them, from the paper they were writing on, to the pen in their hand. The notion of 'making life easier' was mentioned by 31 participants, with three highlighting sustainability and understanding the world around us. Commencement understandings tended to focus on technology as a noun ('things' such as computer, television, phone etc.) whereas completion understandings focused on technology as a verb (process, state or action) including problem solving, sustainability designerly thinking etc.).

#### Changing Beliefs about Design and Technology Education

Pre-service teachers' initial understandings of the learning area were diverse (see Table 4). Notions of critical and creative thinking and doing were highlighted by 43 participants, with a further three identifying Design and Technology Education as an opportunity 'to think outside the box'. A further 27 participants noted the practical and hands-on approach to learning, with eight indicating that it was premised on problem-solving and two noting the independent and collaborative opportunities for learning. Eighteen pre-service teachers likened the learning area to either 'tech studies', 'woodwork', 'metal work', 'cooking' and 'arts and craft', presumably because their understanding was based on their own schooling experiences. In total, 12 participants perceived the learning area to be based on designing and planning, with a further four refining this perspective to link a task/brief to align with the needs of a particular audience, or as one individual described, it is about '*turning ideas in to outcomes*'. Similarly, the concept of designing solutions for an authentic need was raised by four participants, with a further two connecting design to 'real life' situations. Understanding of technology within a historical context was also raised, with 12

pre-service teachers commenting on the design, creation and consideration of technologies past, present and future, or as one person stated, '*it is about analysing and critiquing what was and is around us*'. Thinking innovatively and problem-solving to produce improved outcomes was noted by 16 participants, with the processes of investigating, generating and producing ideas and outcomes raised by eight. As one pre-service teacher noted, Design and Technologies involves '*identifying and analysing problems to create practical solutions that transcend theory*'.

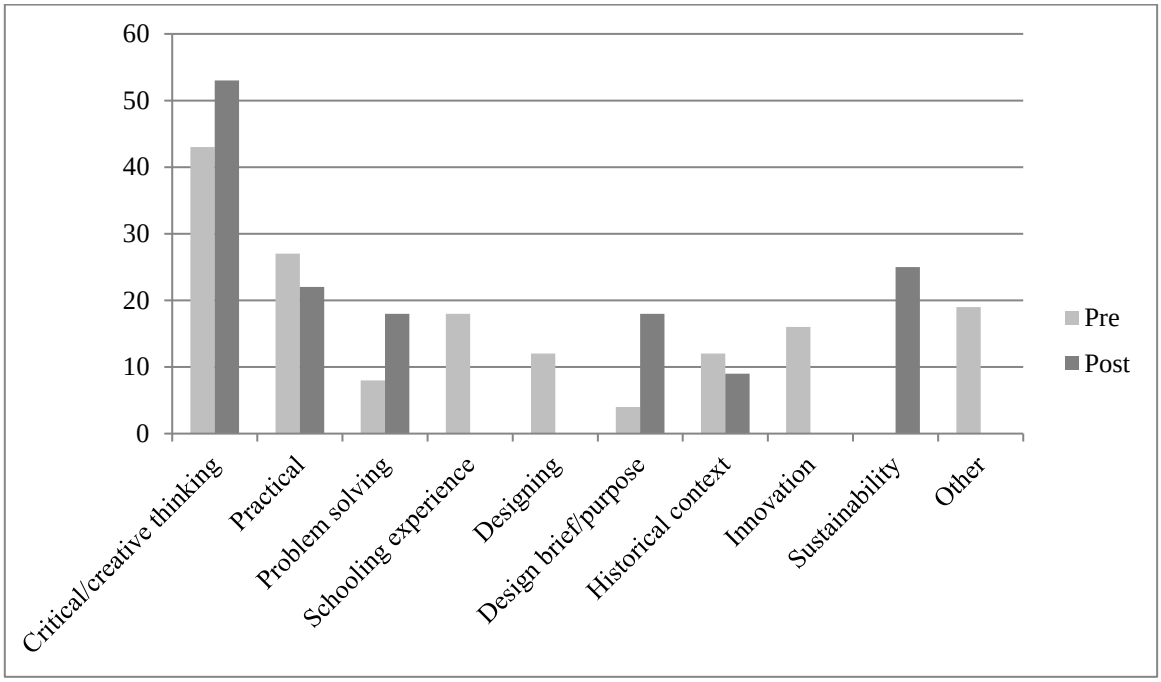


**Table 4: Changing beliefs of learning area**

Analysis of participant responses revealed a distinct difference in the depth of understanding regarding the learning area upon course completion (see Table 4). For example, 53 participants perceived the learning area to be premised on creative and critical thinking, where they worked collaboratively to apply learning. The concept of designing for sustainability and sustainable futures underpinned the beliefs of 25 respondents. While futures perspectives were noted by pre-service teachers, nine mentioned that the learning area involved working with a range of technologies from the past, present and '*the world we live in*', where they learned about technologies across cultures, societies and contexts. This belief was further expanded upon by one participant who noted, '*Design and Technology Education is about critical and creative thinking to create sustainable, preferred futures. Students consider culture, religion and equity in designs to create technologies to best suit needs of societies*'. Broader thinking was evidenced by one participant who commented, '*the learning area is about teaching students to acknowledge the impact technologies have on their lives and the world*' and another who wrote, '*it's about teaching students how to create solutions for real problems that work in more than just a theoretical context'*. Further, as one pre-service teacher commented, '*Design and Technology Education is learning about how local and global problems are solved*', with another stating, '*I learned how the use of design can impact people and work. This is the learning area for creative thinking*'.

The notion of Design and Technologies centring on purpose and purposeful design was also evident, with 18 participants alluding to the learning area fostering learners to creatively and critically engage in activities to devise *appropriate* solutions. In doing so, pre-service teachers commented upon the practical, hands-on aspect of the course, where they

developed the capacity to devise lessons, locate resources, and incorporate newly acquired skills (n=22). The concept of investigation was likewise reported with problem-solving highlighted by eighteen. As one participant reported, '*integrating creative and innovative tasks to the curriculum provides students with opportunities to investigate and discover through their learning. Educators need to facilitate this to help students grow through investigation*'. Other comments included:

> *Design and Technologies is about generating ideas and problem solving. It's about pushing ideas to the next level. It's about being hands-on, creative and innovative. Design and Technologies gives thought to process and making. It's about allowing students a practical area to apply their learned skills*.

Pre-service teachers similarly noted the practical experience they gained throughout the course, with seven addressing the developed understanding of systems (fostered through weekly design brief tasks) and how these can be integrated across the curriculum. As one participant reflected, '*Design and Technologies is about planning and critiquing designs for future technology … it's a stepping stone for students to have an impact on society and also teaches them many skills required for other subject areas*'. As one participant suggested, '*Design and Technologies is about conceptual ideas being made in to useable solutions*'.

As Brownlee, Purdie and Boulton-Lewis (2001, p. 247) have hypothesised, supporting pre-service teachers 'to know and learn more meaningfully would enable these prospective teachers to promote similar learning outcomes in the primary school children for whom they would ultimately have responsibility'. Importantly, findings from this research support the work of Pajares (1992, p. 311) in describing teachers' beliefs as 'far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behaviour'. For this reason, it is imperative that experiences within higher education foster beliefs which are conducive to relevant, rigorous and responsive teaching and learning. In particular, such experiences should translate from practice into beliefs (and indeed, from beliefs to practice) that inspire and motivate pre-service teachers to want to teach in learning areas which previously held little regard or priority for them.

#### Learning through Doing: Developing Practical, Theoretical and Conceptual Skills and Understanding

Analysis of pre-service teachers' expectations of the course suggested they wanted to develop their understanding of content (subject knowledge) to effectively incorporate (teach) practical Design and Technologies in classrooms (n=82), as well as cross-curriculum integration (n=2) (see Table 5). Perhaps due to the prevalence of participants basing their understanding of Design and Technologies on previous schooling experiences, 21 indicated that they expected to gain a greater understanding of how the learning area is valued in schools. Personal skills, such as the development of creativity and designerly thinking (n=31), how to use different technologies (n=3) and gaining skills in order to make informed and ethical decisions (n=1) were highlighted. Likewise, pre-service teachers also addressed the professional skills they expected to develop: three expected to learn to teach students how to problem solve, and three expected to learn how to foster students' communication skills.

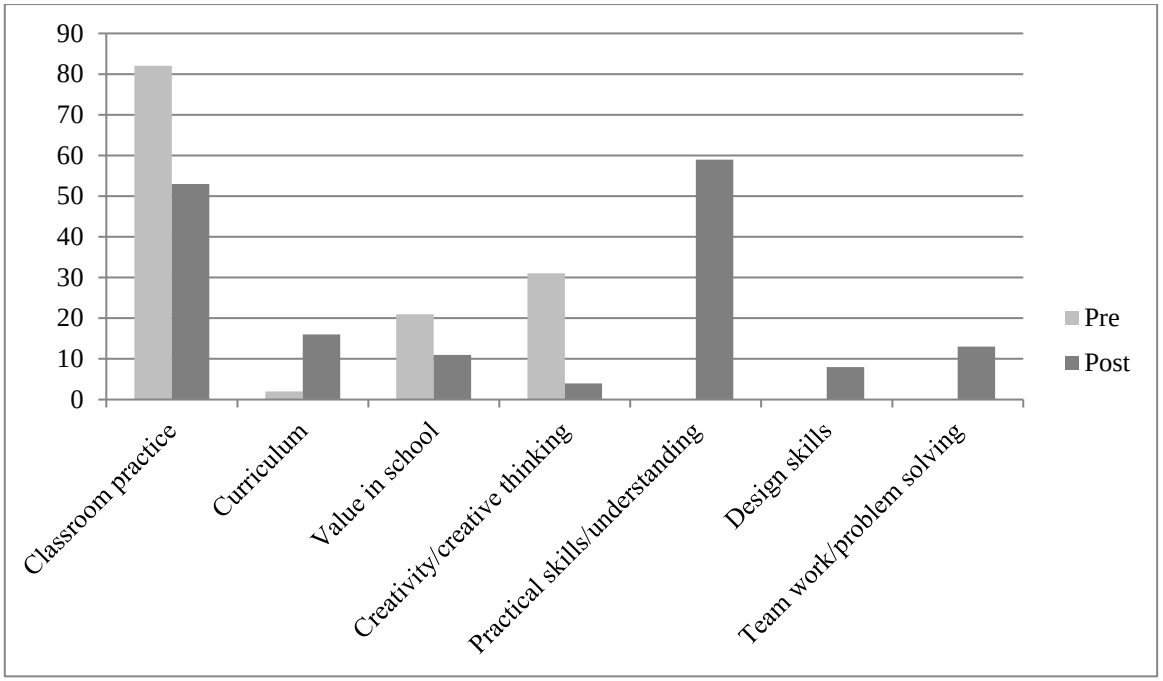


**Table 5: Expected and realised outcomes**

Two key findings emerged from analysis of pre-service teachers' comments at the completion of the course regarding their own skill and knowledge acquisition (see Table 5). First, the development of practical skills, knowledge and understanding was a key learning for pre-service teachers, with 59 commenting on their conceptual and practical understanding of technological systems and food and fibre production. The development of design skills (n=8), team work (n=8), problem solving (n=5), time management (n=3) and creative thinking (n=4) were similarly reported. One pre-service teacher commented, '*I had the chance to work on designing things I have never heard of before. And I felt that I was good at it*'.

Secondly, 53 respondents reported a better understanding of how they may transfer on-campus workshop activities and understanding to classroom application (curriculum and pedagogy) and lesson ideas, indicating an increased sense of confidence and competence. Developing an understanding of the Australian Curriculum was further recorded by 10 pre-service teachers, with 11 commenting on the value of such learning in school classrooms. However, six respondents extended this understanding to comment on the cross-curricular opportunities that Design and Technologies presents. One comment conveyed, '*I learned how to incorporate the course in to my teaching and how it spreads across learning areas. I didn't realise the extent that Design and Technologies could be incorporated in other subjects!*'. Another respondent reflected, '*In doing this course, I learned to believe in myself more; that I am capable of including Design and Technologies in my classroom*'.

Aligning with the initial beliefs of participants within this study, pre-service teachers often felt they lacked the confidence and competence to integrate technology within their classrooms (Tondeur et al., 2011). However, as reported in this paper, such views were countered upon course completion, once students had experienced, in a practical sense, concepts within the Technologies curriculum. While similar findings have been reported in relation to incorporating ICT into teaching (Albion & Ertmer, 2002), it is argued that this would otherwise be the case for systems technologies such as hydraulics, pneumatics, cams and electrical circuits.

**Reflecting on Learning: Transformed Beliefs and Understanding of Design and Technologies**

In contrast to commencement beliefs, where earlier school experiences both directly and indirectly permeated pre-service teachers' understanding of the learning area, course completion data indicated rich and diverse reasoning where responses moved away from superficial experience, towards unpacking the importance of Design and Technologies in the school curriculum (see Table 6). For example, 21 respondents reported the transference of their knowledge, skills and understandings *across* the curriculum, with a further 15 pre-service teachers highlighting the lifelong skills that their prospective students develop. As one participant stated, '*Design and Technologies helps produce students who are informed and creative. It allows children to become critical thinkers and produce effective designed solutions for the future*'. The concepts of sustainability (n=6) and futures thinking were shared by 11 participants. As one explained, '*Design and Technologies is practical and involves complex and creative thinking skills; it involves sustainability and creative preferred futures and allows children to engage in systemic thinking – they understand components of a whole!*'. This view was furthered by two pre-service teachers who commented,

> *By teaching successfully to students, we help aid a better future filled with educated and active citizens*
>
> *This is the subject that fuels creativity, exploration and idea generation. This is where the inventors of tomorrow are born. It's important for children to understand from a young age what Design and Technologies is, so they have greater knowledge of the world which surrounds them.*

Another pre-service teacher reflected,

> *Because Design and Technologies covers a wide range of topics, it is important for students to learn about electrical circuits, food, fibre, textiles so they can make informed decisions as users and consumers. It sets children up for a world where technology and our needs are constantly changing and evolving. It teaches them how to effectively analyse needs in their own lives and create solutions for them in their own creative and unique way.*

Supporting such views, 19 pre-service teachers perceived the learning area to foster learners' 'real world thinking' with the capacity to make informed decisions where they are capable of questioning and understanding where technological products (including food and fibre) are derived.

The importance of learners developing an understanding of the world in which they live was commented upon by several respondents (n=3) who noted the need for awareness regarding everyday items and where they come from. Pre-service teachers similarly valued the learning area as it enabled students to foster problem-solving skills (n=19), collaborative learning (n=4), incorporate hands-on learning to apply practical knowledge (n=10), interpret designs (n=5), challenge thinking (n=3) and think outside of the box (n=24), where '*individuals can be creative and understand that it can be possible to create something without limitations"*.

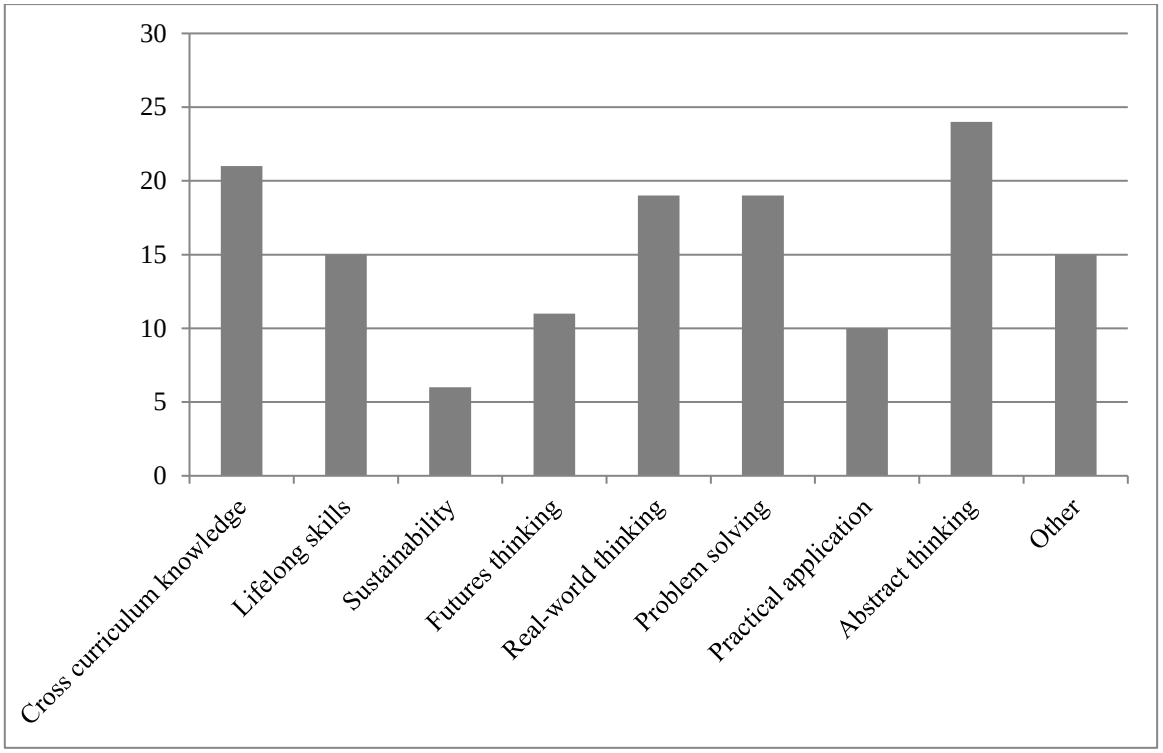


**Table 6: Completion beliefs**

Such findings are indicative of a change in pre-service teachers' beliefs. Although described in reference to inclusive practices, Jordan, Schwartz and McGhie-Richmond (2009) have argued that early teaching dispositions are pliable and are influenced through direct experiences with students in their classrooms. That is, the content conveyed within teacher education courses must relate to real-world settings to enable pre-service teachers to transition between university and classroom contexts. It is for this reason that pre-service teachers were immersed in practical learning experiences, whereby hands-on activities (through design briefs) were employed to further conceptual and theoretical understanding. As Stohlmann, Cramer, Moore and Maiorca (2014) have suggested, teacher education courses should provide opportunities to reconceptualise existing knowledge. They state (p. 4), 'One possible way to do this is to focus on topics that pre-service teachers have learned procedurally in the past and provide them opportunities to reconstruct this content in a more meaningful way'. Although this reference was situated in a mathematics context, is relevant across the curriculum and in particular, Design and Technology Education where there is immense scope to move away from traditional approaches of doing, towards more innovative ways of thinking.

As Lortie (1975) has reported, a pre-service teacher's personal schooling experiences are influential factors in shaping subsequent beliefs regarding their own professional teaching practice. Although it has been contended that these beliefs are entrenched and difficult to change (Pajares, 1992), findings from this study suggest that greater awareness and understanding of a particular learning area can affect beliefs. In many cases, mere exposure to resources and practical experience with Design and Technologies concepts enacted considerable development in understanding.

## Conclusion

This paper has focussed on the developing understandings of first year pre-service teachers as they engaged in a twelve week Design and Technologies course as part of their undergraduate Bachelor of Education program. Findings from this study suggest that pre-service teachers enrol in particular courses with preconceived ideas, often formulated in response to their own schooling experiences. However, as the commencement and completion data conveyed, immersion in frequent, hands-on Design and Technologies experiences which is underpinned by relevant, rigorous and meaningful learning experiences presents great scope to challenge and broaden pre-service teachers' theoretical, conceptual and practical understanding of the learning area. While this paper has reported upon the changing beliefs and understandings about Design and Technologies, it is highly likely that pre-service teachers' thinking was challenged and extended even more so than this paper has reported. As Pajares (1992) has posited, beliefs can be viewed as the rationale underpinning action. Therefore, if higher education courses can positively shape pre-service teachers' perceptions regarding a learning area, they are more likely to integrate such learning experiences in to their subsequent classroom settings.

Although teacher preparation programs have attracted criticism for the apparent disjuncture between university and school settings, theoretical, conceptual and practical understandings must connect to real-world practice to enable pre-service teachers to understand the rationale behind incorporating technologies (not limited to information technologies) in to their practices (Tondeur et al., 2011). That is, the nexus between theory, concept and practice has direct bearing on a teacher's philosophy, pedagogy and practice. As Brownlee et al. (2001) have advocated, higher education must push beyond mastering specific content as a desired outcome and, instead, consider knowledge as personally constructed based on relevant content. This is particularly relevant to the learning area of Design and Technologies given the rapidly changing contexts which we inhabit and the need for creative, critical and responsive thinking. Yet, at the same time, higher education needs to be responsive to changing contexts. As such, findings from this study have invariably informed subsequent iterations of the Design and Technologies course. That is, pre-service teacher education must not only reflect contemporary issues, but it must also foster a depth of theoretical and conceptual understanding of a particular learning area. Within Design and Technologies, learning must be rigorous and relevant, but it must also provide opportunities to employ practical experience that is transferable to classroom settings.

Exposing pre-service teachers to the cross-curricular opportunities that a learning area such as Design and Technologies provides supports future educators to integrate practical hands-on learning experiences amidst a competing and overcrowded curriculum. In order to challenge and inspire pre-service teachers' thinking and application of knowledge, they must be afforded experiences that carefully balance autonomous and collaborative learning with structured and experiential learning. In challenging traditional understandings of the learning area as being 'technical studies' or 'information processing', this study has demonstrated that undergraduate courses influence leaners' thinking. In particular, upon completion of the course, pre-service teachers were increasingly likely to perceive Design and Technologies to centre upon opportunities to think critically and creatively, rather than a learning area which simply 'makes things'. As pre-service teachers have highlighted, the learning area is not premised on expensive or hard-to-source resources, but rather, using accessible and economical resources in innovative and purposeful ways. That is, it is a way of thinking, as opposed to a way of doing. In challenging participants' early beliefs, technology must be considered in a broad sense; in doing so, it is contended that access to computers, specialised equipment or expensive resources is negated. In particular, this paper argues that technologies

and technological artefacts are a product of innovative, inventive and creative thinking: they are often derivatives of reused, recycled or reconsidered resources.

As Pajares (1992) has reported, beliefs are more influential than knowledge as a determinant to behaviour. This is a particularly pertinent point for pre-service teacher education as rigorous, relevant and responsive learning experiences present immense scope to positively enrich understanding and the likelihood of shaping subsequent teaching experiences. To advance these findings, future studies may benefit from capturing the perceptions of pre-service teachers as they embed their learning in to real-world teaching experiences. That is, while higher education courses serve to support pre-service teacher knowledge and understanding, how such experiences serve to shape pedagogy over time remains an area for further investigation. Although this study captured the beliefs and perceptions of first year pre-service teachers, further research may extend findings through more specifically exploring how first year experiences can be sustained through to in-service teaching.

Drawing on the experiences of first year pre-service teachers, this paper has portrayed how their understandings, beliefs and perceptions of Design and Technologies were challenged, broadened and influenced through immersion in the learning area. Given the emphasis on hands-on learning and practical experiences throughout the course in which this study focussed, such a finding illustrates the influence that first-hand learning has on developing pre-service teachers' theoretical, conceptual and practical beliefs and knowledge. While this paper has focussed on key concepts within Design and Technologies, it is contended that such conceptual understanding can enrich pre-service teachers' capacity for curriculum integration and cross-curricular learning experiences. That is, exposure to the learning area has created awareness of how critical and creative thinking transcends across learning areas and are arguably, key dispositions that are valued and vital both within and beyond school and classroom settings.

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