

Developing Design Thinking Expertise in Higher Education

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Abstract: *Design Thinking describes a human-centred methodology for innovation, which has evolved from the study of the unique ways in which designers 'think', and 'practice'. There is growing evidence of the increased uptake of Design Thinking in design, business and other disciplines, and there is an emerging body of research. There is a need to develop sound University curricula that are founded in relevant theory and research findings, however, there appears to be a relatively small amount of rigorous research on the learning and teaching of Design Thinking. This paper presents the initial stages of a PhD research project that explores how Design Thinking can be best developed, delivered and evaluated in higher education to both product design and business students. The evaluation focuses on the students' learning and teaching experiences, and the impact of the curriculum on the development of their Design Thinking expertise. The research uses Action Research, Design, and embedded Case Studies. A number of key theories inform the curriculum including Design Thinking, Constructivism, Experiential Learning, Bloom's Learning Domains and Constructive Alignment. The paper presents initial research findings from the first iteration of the curriculum.*

Keywords: *Design Thinking, Curriculum Development, Learning and Teaching*

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Introduction

The overall aim of this research project is to explore how Design Thinking expertise can be best introduced, developed, nurtured and enhanced within both Product Design and Business higher education programmes. Specifically, a Design Thinking curriculum is being developed, evaluated and refined through a number of iterations. For the purpose of this research, a curriculum is defined as a learning and teaching programme for the introduction and development of Design Thinking expertise. The research specifically aims to: (a) evaluate the impact of the curriculum on students' learning and teaching experience, and their development of Design Thinking attributes and capabilities; (b) identify factors that influence the impact of the curriculum on students' learning experiences and achievements; and (c) assess the use of action research as a methodology for both improving teaching practice and developing personal learning and teaching theory in relation to design thinking.

Currently, there is limited research on the learning and teaching of Design Thinking. Consequently, this research will make a significant contribution to related scholarship and offer significant contribution to developing a deeper understanding of:

- The knowledge, cognitive capabilities, thinking styles attitudes and values, methodologies and methods associated with design thinking expertise;
- The perspectives of students, teachers and business professionals concerning design thinking;
- The features of a curriculum and resources that can support students' learning of design thinking expertise;
- How design thinking can be best taught, nurtured and enhanced in higher education and professional learning contexts; and
- The methodologies and methods that can be used to design and evaluate Design Thinking curriculum and resources.

Design Thinking

Design Thinking is founded on the notion that many designers 'think' and 'practice' in particular and unique ways in the creation of products, graphics, artefacts, environments, buildings, systems and services, and that this way of 'thinking' can be studied, harnessed and improved. Design Thinking can be conceived as a 'human-centred methodology' (framework) that supports and drives effective innovation (Bauer and Eagen 2008). The usefulness of Design Thinking in tackling complex or 'wicked problems', as opposed to well defined problems is important (Cross 2001; Buchanan 1992). "Wicked problems are complex that they cannot be analysed and fully understood in order to be solved afterwards by rationalistic scientific processes, but should instead be reframed and addressed through an iterative processes by the designers involved" (Poulsen and Thogersen 2011).

Design Thinking is a useful methodology for exploring complex and complicated problems, and it is now being taken up and utilised by a range of disciplines and professions outside of design to drive innovation (Bauer and Eagen 2008; Kolb 1984; Martin 2009; Leavy 2010). These disciplines include architecture and engineering; information and technology; business and management; and education. Design Thinking has also had increasing uptake in areas such as sustainability and social

innovation. Much of the rise in the recognition, study and application of Design Thinking can be attributed to specific businesses and organisations such as interdisciplinary design consultancy IDEO, who have developed key Design Thinking models and practices; academic institutions such as the 'd' school at Stanford University and the Chicago Institute of Design, which have developed undergraduate and postgraduate learning and teaching programmes and workshops informed by Design Thinking. In addition, Toronto's Rotman School of Management has been instrumental in promoting Design Thinking management education.

Conceptualisations of Design Thinking

A number of researchers offer conceptualisations of the cognitive processes that are manifest in Design Thinking. For example, Bauer and Eagen (2008) propose that Design Thinkers use a generative process of 'imagining' to drive the idea creation process. Imagining relies on analytical, associative thinking and day dreaming (Bauer and Eagen 2008). Cross (2011) describes the designer's ability to move between the concrete and abstract modes thinking modes as central to Design Thinking. The literature review has revealed that a wide range of thinking capabilities and styles have been associated with Design Thinking. These include: constructive (concrete) thinking; analytical (critical) thinking; abstract thinking; divergent/convergent thinking; synthetic thinking; abductive reasoning; intuition; reflection, visualization; heuristical thinking, aspirational thinking, synaptical thinking and hypothetical thinking.

Cross (2008) identifies various forms of intelligence that may be drawn on in Design Thinking. They include: Linguist; Logical Mathematical; Spatial; Musical; Bodily-Kinaesthetic; and Personal. Goldschmidt and Badke-Schaub (2008) present a model of cognitive processes including Search/Generation/Mental Imagery/Evaluation Assessment/Structuring Learning as well as Visual Thinking and Design Reasoning. They advocate that design researchers work with psychologists to investigate these cognitive processes. Owen (2007) represents Design Thinking as knowledge building situated between analytic 'finding' and synthetic 'making' modes of cognition (see fig 1). Cross (2008) also argues that more work on understanding the cognitive aspects of Design Thinking will empower design educators in formulating their aims, objectives and methods

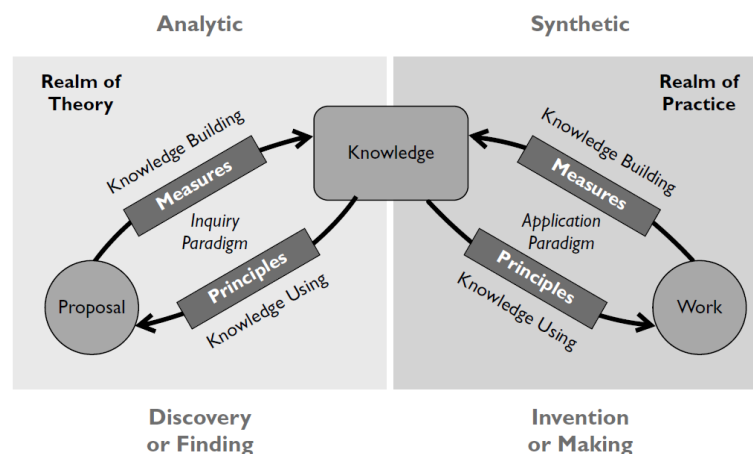


Figure1 Design Thinking as knowledge building. Source Owen, 2007.

Dunne and Martin (2006) describe Design Thinking as the reverse of scientific thinking: where as the scientist analyses facts to discover patterns, the designer invents new patterns and concepts to address facts and possibilities: "Design Thinking includes inductive, deductive and abductive reasoning" (Dunne and Martin 2006, 517). Brown (2008a) states that Design Thinkers not only rely on analytical processes (those that produce either/or choices) but also exhibit the ability to see and grasp all of the key and sometimes-contradictory aspects of a problem and synthesise new solutions that go beyond and dramatically improve on existing alternatives. In this sense Design Thinking is a Creative Thinking process.

Various researchers propose that many designers have a different outlook or worldview that is underpinned by particular values and attitudes. For example, Lockwood (2010) refers to Design Thinkers applying a designer's sensibility and methods to problem solving, no matter whatever the problem is, and Brown (2008) states that designers have an ability to imagine the human world from multiple perspectives, for example those of colleagues, clients, end users, and customers (both current and prospective). Values and attitudes identified in the literature on design thinking include optimism, empathy, embracing of the radical; sensitivity, a questioning attitude, sustained curiosity, playfulness, tolerance for ambiguity, systemic vision, personal courage, asymmetrical thinking, sustained curiosity; ability to maintain sight of the big picture, and tolerance of uncertainty.

In contrast to the many publications that paint a sometimes 'idealistic' picture of Design Thinking's contribution to design, innovation and to other professions such as business, Badke-Schaub, Roozenburge, and Cardoso (2008) take a more critical view and state that many of the claims regarding Design Thinking are not supported by empirical evidence. Carr, Halliday, King, Liedtka, and Lockwood (2010) examined the influence of Design Thinking on business and found that many managers found the term Design Thinking confusing, and that there was much disagreement of its value as an innovation tool. Newman (2011), claims that Design Thinking's time has not come, and that many companies that conceptually invested in Design Thinking have not yet seen the results on innovation that it promised.

The implementation of the design thinking capabilities and attributes previously identified is associated with varied methodologies and methods or process models. It is important to note that Design Thinking is frequently emphasised as a collaborative process. For example, Brown (2011) observes that the increasing complexity of products, services, and experiences has replaced the myth of the lone creative genius with the reality of the enthusiastic interdisciplinary collaborator. The best Design Thinkers do not just work alongside other disciplines; many of them have significant experience in more than one discipline (Brown, 2011).

Design Thinking Education

In parallel with the uptake of Design Thinking across a range of disciplines, there has also been an increase in the learning and teaching of Design Thinking in universities and institutions of higher learning. However there is a relatively small amount of research published on the learning and teaching aspects of Design Thinking. Much of this literature expresses a range of views about learning teaching and assessment approaches and practices that facilitate learning of Design Thinking capabilities.

For example, Dunne and Martin (2006) contend that the teaching of Design Thinking has the potential to positively influence business and management education, specifically MBA programmes. They argue that management has many parallels in design, and that while applying design approaches to management is relatively new, and with a drive for innovation in businesses, there are many opportunities to do this. In response to this emergent opportunity, business schools need rise to the challenge and develop new courses in Design Thinking (Dunne and Martin 2006). "Under a design-thinking paradigm, students would be encouraged to think broadly about problems, develop a deep understanding of users, and recognize the value in the contributions of others" (Dunne and Martin 2006, 512). They argue that this will be achieved through 'epistemological pluralism', which would involve teaching the 'standard' models currently taught in business schools, in addition to a Design Thinking approach.

A number of engineering schools have developed approaches to teaching Design Thinking. For example, the d.school at Stanford University, one of the leading multi-disciplinary engineering and design schools, is well known internationally for developing and incorporating Design Thinking in its programmes. Plattner et al. (2011) describes the key philosophy and approaches used in design courses at the Stanford's School of Engineering. They identify that the teaching of interdisciplinary collaboration is fundamental to this approach. "Design thinking students learn in interdisciplinary teams how to tackle a given design problem by exploring it's (sic) problem space with a hands on approach" (Plattner, Meinel, and Leifer 2011, 14).

Design Thinking Curriculum Development

A small number of authors have extended the literature to discuss the development of Design Thinking curricula in higher education. Melles and colleagues (2008, 2011) describe the development of a university based Design Thinking Unit, which delivers a course in Design Thinking which is underpinned by a Design Thinking 'mindset' model developed by the Stanford d.school (Empathy/Define/Ideate/Prototype/Test) (Anonymous 2010). The authors provide some reference to the deeper pedagogical underpinnings of the course, such as epistemological position and learning and teaching approaches, or Design Thinking capability development. In addition, they provide useful reflections on the results and lessons learnt to date, specifically concerning the difficulties in teaching an inaugural course on Design Thinking.

Eagen, Aspevig, Cukier, Bauer, and Ngwenyama (2011) state that in response to a demand for innovation, business programmes are emerging which embrace multi-epistemic modes of Design Thinking. They explore the pedagogical models used to teach design thinking in business programmes and identify multiple ways of knowing including (capabilities), cognition, emotion, sensation and intuition as central to Design Thinking. Skills such as imagination, interrogation and play are identified as playing a key role in dealing with undefined, incomplete, 'wicked problems'. Eagen et al provides in-depth discussion of the role, and pedagogical implications of: Intuition, Empathy, and Action Learning. However, while there is in-depth discussion of the pedagogical shifts needed in moving to teaching Design Thinking in business schools, there is very little discussion of the practical implications of this, and/or examples of how and where this has happened.

Beckman and Barry (2007; 2008) describe the development of a postgraduate business course in Design Thinking and cross-disciplinary management. In discussing

the underlying approach to teaching the course, the researchers identify significant parallels between Owen's (2007) view of the field of Design Thinking, and Kolb's (1984) Experiential Learning Theory. Owen outlines how Design thinking is different from other types of thinking, and provides a framework based on a map of four fields in relation to context and process from symbolic (abstract) to real (concrete) and from analytic to synthetic (see figure 2).

The literature review indicates that:

- Design Thinking is emerging as a 'discipline' area, and the body of research is growing;
- Given the uptake of Design Thinking across many disciplines and professions, there is a need to develop sound curricula that are founded in relevant theory and research findings;
- While there is emerging research into the learning and teaching of Design Thinking (descriptions, examples and case studies), it is largely anecdotal and reflection rather than research-based, and there is general lack of rigorous evaluation of curricula;

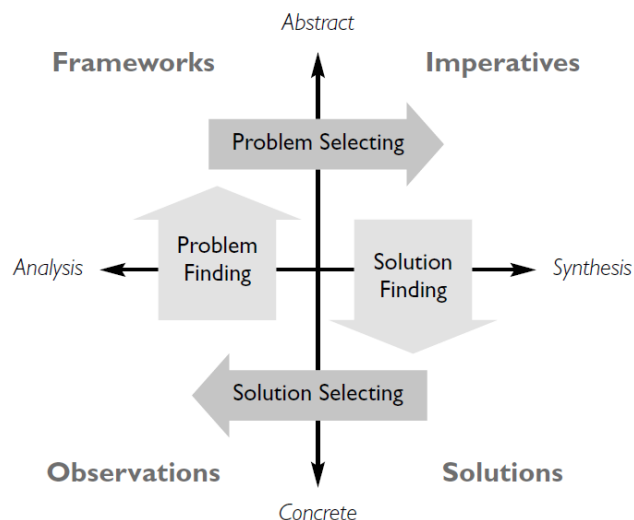


Figure 2 Adaption of Kolb's (1984) Experiential Learning Theory model mapped against a Design Thinking process. Source: Barry and Beckman 2008.

In light of this summary, there is a strong case for a research project in which:

- Priority is given to exploring how Design Thinking expertise can be effectively introduced, developed, evaluated and enhanced in higher education contexts;
- The development of a Design Thinking curriculum is underpinned by a clear and coherent conception of design thinking as well as recognised learning and teaching constructs, models and theories (see next section); and
- Rigorous research is used for the development, evaluation and fine-tuning of a design thinking curriculum and associated resources.

Research Design

The PhD research is underpinned by a paradigm position of *Critical Realism* (Healy and Perry 2000). Within the Critical Realism position, the epistemological position is *Relativist*. The research uses an *Action Research* methodology that incorporates both *Design* and *Co-Design* methods. It also uses an embedded *Case-Study* design and involves the use of *Multiple Methods* for the gathering and analysis of both *qualitative* and *quantitative* data.

Action Research, defined as "systemic inquiry that is collective, collaborative, self-reflective, critical and undertaken by participants in the inquiry" (McCutcheon and Jung 1990, 148) was selected as the overarching methodology specifically because of its cyclic and iterative approach to research i.e. the Design Thinking curriculum is developed through a number of design iterations. According to Barab and Squire (2004,) a Design-Based research approach, as opposed to more traditional Hypothesis-Based research approach, uses design processes to iteratively develop new theories, artefacts, and practices and is particularly useful for research in educational contexts. In essence, the design process itself becomes a research process. This approach is compatible with Action Research. In particular, Co-Design, sometimes called Participatory Research (Bryman and Bell 2007), is used as a key design strategy. Co-Design/Participatory Research involves participants as active collaborators in the research and design process.

In addition, the use of case studies aligns specifically with a concern to capture rich and deep insights into the experiences and the learning of students, accompanied by explanation for tendencies, trends and impact factors. In this instance the explanations link curriculum implementation the curriculum's effects and impacts (Yin 2003). Multiple case studies also enables the researcher to "explore differences within, and between cases" (Baxter and Jack 2008, 548). In this project, the multiple case studies are embedded as they include individual students and groups of students.

Learning and Teaching Theory

It is essential that the development of the Design Thinking curriculum be situated within appropriate learning and teaching theories and constructs. The following theories have been utilised:

A. Constructivism/Constructionism. The constructivist and constructionist approaches to learning and teaching emphasises student-centred, or student-directed learning. Internationally, constructivism has been a key part of educational discourse for more than twenty years (Conole and Alveizou 2010);

B. Experiential Learning. Experiential Learning Theory (ELT) emphasizes and values learning through 'reflection on doing', which is can be contrasted with rote or didactic learning. "Knowledge results from the combination of grasping and transforming experience" (Kolb 1984, 41). The ELT model portrays a cyclic models of four related modes of grasping experience: concrete, analysis, abstract and synthesis (Kolb, Boyatzis, and Mainemelis 2000);

C. Learning Domain Taxonomies: Bloom's (1965) taxonomy of learning objectives in the cognitive, affective and psychomotor domains provides an appropriate framework for identification of relevant learning and outcomes. A modification of this taxonomy must also be taken into account Dettmer, (2006). Dettmer (2006) adds ideation and creativity to the cognitive domain and internalization, wonder, and risk taking to the

affective domain. These changes are closely correlated to the key principles of Design Thinking; and

D. Constructive Alignment: Constructive Alignment (Biggs 1996) has its roots both in constructivism and curriculum theory and emphasizes a necessary connection between a constructivist understanding of the nature of learning, and an 'aligned' design for an outcomes-based teaching education. It is the aligning of desirable learning outcomes, and learning activities with assessment (Jones 2006). Constructive Alignment can also be perceived as a systemic theory that regards the total teaching context as a whole, as a system (Brabrand 2007).

Data Gathering

Data is obtained from the following participant groups:

Researcher-Designer: Includes the researcher's ongoing personal reflections, thoughts, experiences, observations, and records of interactions (both tacit and explicit); and

Students: The student participants are drawn from two distinct groups: (a) approximately 50 first year Product Design students undertaking a paper titled Product Design Studio II in the three year, Bachelors of Design programme; and (b) approximately 100 first year business students, undertaking a paper titled Design Thinking in a Bachelor of Business programme.

All students enrolled in the two papers (above) are invited to participate in a 'pre', and 'post' Design Thinking curriculum survey and complete a portfolio of Design Thinking practical work and a stratified sampling case frame was developed to identify a purposive sample of students to participate in key informant interviews. In addition all students participating in the research were also invited to participate in creative co-design sessions in which they help co-design improvements to the Design Thinking curriculum (based on initial findings of the research) and their own experiences.

The qualitative data is analyzed using both inductive and deductive methods. It is anticipated that a variety of forms of inductive analyses will be appropriate (e.g. constant comparison, content analysis, domain analysis, taxonomic analysis, componential analysis, retroductive analysis). The quantitative data is analyzed using simple Descriptive Statistics to describe the basic features of the data in a study and uncover patterns or general tendencies in a data set ("Descriptive statistics" 2004). Ethical approval for this research was gained from the University Ethics Committee.

First Case Study (Iteration One)

Informed by the researchers previous experience of teaching Design and Design Thinking, the findings of the literature review, a visit to the d.school at Stanford university to observe a Design Thinking 'Boot Camp' for executives in action, and a review of the core learning and teaching theories, the first iteration of the Design Thinking curriculum was developed and taught to 25 first year product design students.

A key approach to the curriculum development was to interrogate the existing Stanford University d.school 'Bootcamp' workshop model (a model widely used in professional situations) and strategically evolve it into a four-week, 9 hours per week, studio model suitable to a university product design programme. The curriculum was structured into 12 sessions. The aim of the curriculum, in this instance with product design students who already have some familiarity with design processes, was to

introduce a formal Design Thinking model (methodology), as well as Design Thinking principles, methods and tools, and to develop students Design Thinking expertise.

The curriculum development process involved conceptualising and designing a detailed four-week teaching plan including a six-stage Design Thinking process model (See figure 3), learning goals, structured session plans, presentations, learning activities, project brief, assessment criteria and deliverables. Stages 2, 3, 4 and 5 of the Design Thinking process model correspond to Kolb's (1984) Experiential Learning model and the work of Barry and Beckman (2008) on how a cyclic processes of analytic/abstract/synthetic/concrete thinking relate to learning and the Design Thinking process. Specific consideration was also given to the development of an overall learning and teaching environment that reflected constructivist principles. This included providing a variety of learning activities from structured to semi-structured, through to independent and self-directed, and to allow for as much student tutor interaction and discussion as possible.

A detailed Design Thinking Methods resource was also developed to accompany the curriculum. The resource is structured around the Design Thinking model and presents a summary of each of the key methods within each stage. Within each method an introduction provides an overview, followed up by more detailed information on using the method and examples/case studies with links to relevant videos are also included.

Integral to the curriculum development was the identification and development of key learning goals and an assessment framework. The learning goals, based on key conceptualisations of Design Thinking expertise, and align with Blooms (1965) domains of learning. The learning goals were then developed into assessment rubrics, and a self-reflection tool for students (see figure 4). Constructive Alignment was utilised as a key theory to maintain alignment between the learning goals, learning and teaching process and the assessment framework (Biggs 1996).

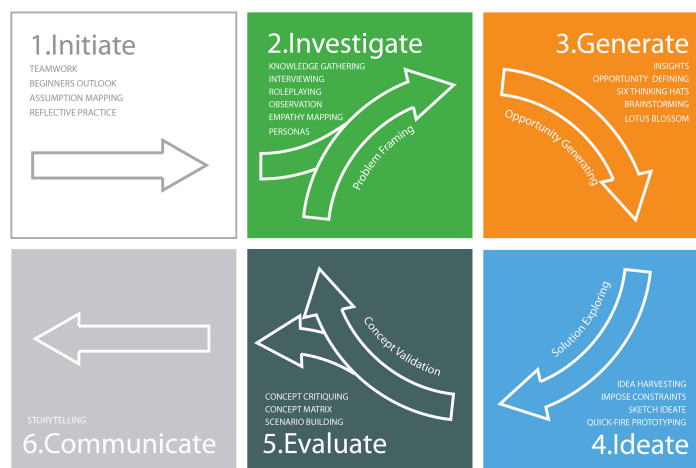


Figure 3 Model of the Design Thinking process developed for the curriculum.

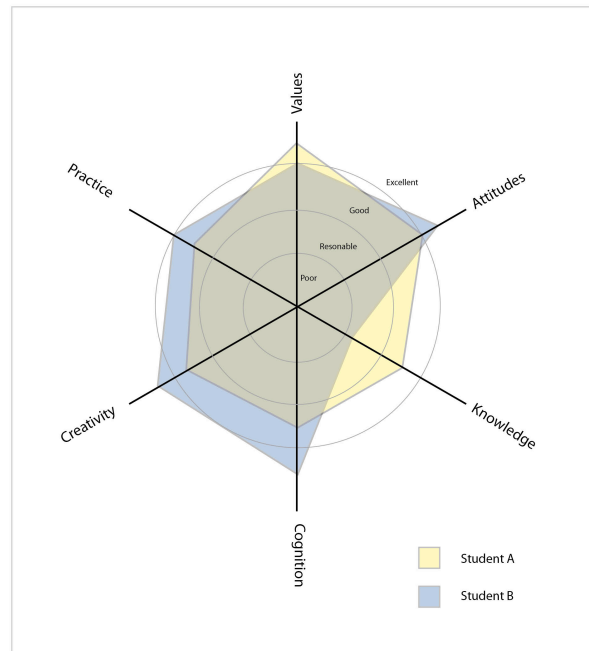


Figure 4 Example of a spider diagram to help student's self-assess their Design Thinking expertise.

A project brief, reflecting an appropriate, relatively undefined, but user-centred design problem, was then developed. In this instance the brief asked students to collaborate in groups of three to undertake in-depth research, analysis and the design of one or more innovative 'design interventions' that clearly improve and enhance the experience of ferry patrons at the downtown Auckland ferry terminal. The emphasis here is on the design interventions that enhance user experience, rather than just products.

Following a detailed briefing the researcher, the curriculum was delivered by two design lecturers. Each of the 12 sessions consisted of a tightly scripted structure usually starting with a key multimedia presentation, followed by a structured and semi-structured learning activities linked to the project. In addition student groups were asked to develop a portfolio documenting the Design Thinking process and following the key steps in the Design Thinking process model. Students were also asked to individually self-reflect after each session via a journal (in this case via an online blog) on their personal learning development using the learning goals framework.

Initial Analysis

At the time of writing the first iteration of the Design Thinking curriculum has been delivered, and the students have completed both the pre and post curriculum surveys. Within the next few weeks key informant interviews with a random sample of the participants will be completed, and portfolios and blogs will be reviewed. A co-design session with students will be undertaken to explore ideas for improvement to the next iteration. The researcher has also completed a detailed reflection of the curriculum

development process, including informal and ongoing discussions with the teaching staff. An initial review of the survey data has been completed by the researcher and indicates that:

- The majority of participants had a reasonably high i.e. adequate/good range personal rating of their design thinking expertise pre the commencement of the project;
- Student's personal ratings of their design thinking expertise increased to the good/excellent range post the curriculum;
- 92% of students rated the overall learning and teaching approach was either good or excellent;
- 88% of students rated the curriculum structure (i.e. each session having a clear workshop style and approach based on the d.school 'Bootcamp' model) as good to excellent;

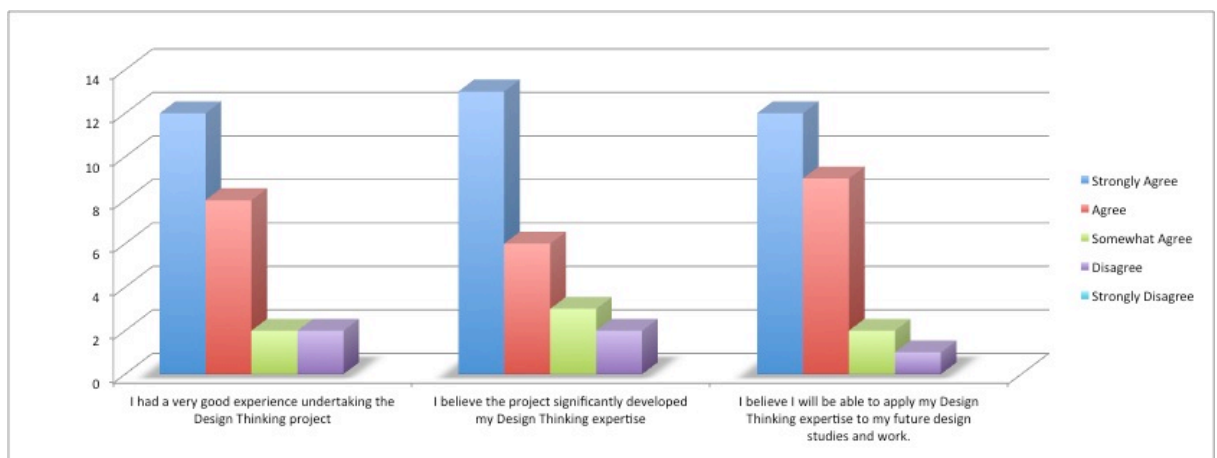


Figure 5 Graph showing students ratings of their experiences of the Design Thinking curriculum, and their perceptions of the impact that it had on their learning.

- Students identified key aspects of the curriculum as particularly useful including the presentation content, videos and resources as very helpful/extremely helpful to their learning;
- 79% of students of students agreed or strongly agreed that they had very good experience undertaking the curriculum (project);
- 88% of students considered the curriculum significantly contributed to the development of their Design Thinking expertise; and
- This positive feedback regarding overall students experience and the perceived value of the curriculum seemed to validate the overall learning and teaching approach.

Arising from the researcher's more general reflections on this opening phase of the research were insights into research that requires the collaboration of teacher colleagues. The briefing of colleagues who taught the curriculum needed to encompass their knowledge of the goals and theoretical underpinnings of the research as well as

the curriculum, and take into account their initial differing conceptualizations of Design Thinking. Their involvement also meant that some aspects of the curriculum and pedagogy were more tightly structured and scripted for the first iteration than would have been the case if the researcher had been the teacher. Ethics considerations did not allow for this. However, the action research methodology along with a commitment to co-creation of curriculum meant that a more flexible approach might be introduced for succeeding iterations. Certainly, this collaborative process became a strong 'provocation' and helpful 'mechanism' for dialogue around learning, teaching and curriculum development issues.

Conclusions

This paper has presented preliminary findings from the initial stages of a PhD research project that uses action research to evaluate the impact of a Design Thinking curriculum on students' learning and teaching experience and their development of Design Thinking expertise; identify the factors that influence the impact of the curriculum on students' learning experiences and achievements; and to assess the use of Action Research as a methodology for both improving curriculum development and teaching practice.

Although this is the very early stage of the analysis of the first iteration of the Design Thinking curriculum, some emergent issues and opportunities have been identified. It is clear from the initial feedback however that the overall approach using an evolution of the d.school 'Bootcamp' model seems to provide students with a sound learning and teaching experience and that students perceive a positive impact of their Design Thinking expertise. Further research including in-depth participant interviews, a review of student portfolios and self-reflection will be used to more deeply identify, explore and analyse the key mechanisms within in the curriculum that impact Design Thinking expertise development. In addition a co-design session with student participants will be used to explore innovative ideas and improvements to be incorporated in the development of the second iteration of the Design Thinking curriculum. This iteration will then be taught to, and evaluated by, first year business students in semester 1, 2013. The on-going evaluation of the usefulness of this Action Research approach to curriculum development will also continue.

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