Perspectives of academics and practitioners on design thinking

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Additional Information:

- A Doctoral Thesis. Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University.

Metadata Record: https://dspace.lboro.ac.uk/2134/22445

Version: Accepted for publication

Publisher: © Arthur Chan

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Perspectives of academics and practitioners on design thinking

by Arthur Chan

Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University

January 2016

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Abstract

Design thinking has attracted a significant amount of interest and attention from the non-design sector in areas such as finance, government services and transport. This has resulted in new definitions that appear to describe design thinking as the mythical process that generates innovation and as a result, creating confusion and causing some to question its meaning.

Research was undertaken to explore the possible knowledge gap that exists between academic and practitioner understanding of design thinking and its practical application. The relationship between the two has been articulated and a data driven model of design thinking created to further understanding of the meaning of design thinking.

Firstly, an initial literature review was conducted to examine the origins, ownership and relationship between design thinking and four other related terms. Secondly, four common characteristics of design thinking were identified from projects reported by academics and practitioners as examples of the application of design thinking. The literature review provided the point of departure for the design of the empirical research instrument (RI). From the initial literature review four common characteristics of design thinking was identified; they were: ‘drivers’, ‘experts’, ‘impact’ and ‘processes’.

The research methodology employed constructivist grounded theory using a multi-qualitative method to maximise the capacity to gather high quality data. Pilot studies were conducted internally to test out the research instrument. From the pilot studies an additional common characteristic identified: ‘design problem’, being traditional or non-traditional. Following the pilot studies, primary data collection methods of interviews and online survey were employed. A total of 56 participants took part in the study, the participants who took part were academics and design practitioners from around the world. A total of 13 interviews were conducted and 43 survey responses were collected. The interviews and online survey used in data collection formed two stages of a triangulation strategy that was used to explore all the research questions.
Two data sets were created from the interviews and online survey, which were analysed by thematic analysis and content analysis. From the thematic analysis, the five common characteristics identified from the literature review and pilot studies were confirmed; two additional common characteristics were identified as ‘multidisciplinary’ and ‘knowledge’. Content analysis was conducted to identify evidence to describe the 7 common characteristics identified. Furthermore, the modes of expression for design thinking were also identified from the data in order to explore its relationship to design education.

Case study analysis was the third stage of the triangulation strategy employed. It was conducted to check the reliability of the findings. This involved three design school case studies and three practice-based case studies of which two were for product designs and one was for service design.

A qualitative data model of design thinking was developed to present the findings of the research. The research was then validated by a PhD seminar at Lancaster University and a validation study with experienced design practitioners. A final literature review was conducted after the validation studies to compare the research findings to the most recently published literature. From the literature review and validation studies, any appropriate findings were incorporated into the theory constructed.

*Keywords: design thinking, academia, practice, definition and model*
Acknowledgements

I would like to put forward my sincere thanks and recognition to the following individuals, originations and institutions.

I would like to thank my supervisors Dr Mark Evans and Professor Eddie Norman for their guidance and support. Without their wisdom and guidance this PhD simply would not have happened. I will be forever grateful to my supervisors for giving me this unique opportunity to further my knowledge. Thanks also go to my internal examiner Dr Erik Bohemia for taking his time to examine my work throughout the PhD and provide valuable feedback whenever possible.

A big thank you goes to my funding body Loughborough University for putting forward the investment. Special thanks of course go to everybody in the Design School and LDS 1.23 for making me feel at home in Loughborough.

To the 56 participants around the world who kindly gave up their time to take part in the data collection phrase of my research; I would like to thank you all for the insightful information provided, without your participation it would have been impossible to complete the PhD.

I would also like put forward my thanks to Jake Amies; Eleanor Pendlebury; James Roberts; Ross Kemp from ASAP Watercrafts; Loughborough Service Design Jam and Mark Stratford for letting me use their work for case study analysis.

To Dr Martyn Evans and Christopher Boyko from Imagination Lancaster at Lancaster University, thank you for providing me the time and opportunity to validate my research with your PhD students and staff at your department’s PhD seminar. I would also like to thank David Bramley and John Piper for taking their time to validate and provide feedback for the research.

To my Malvern and UWE friends (you know who you are); thanks for the support, constant banter, Xbox Live sessions, Manchester United chats plus moaning sessions, endless car talks and life advice. You lot did a great job of keeping my sanity in check.
Last but not least I like to thank my family; especially my parents for their love and support. Without their support for me (aka the financial black hole of the Chan family, black hole discovered in August, 2000) I would not be doing what I am doing today. A special mention also goes to my cats for keeping my spirits up when I needed it.

*This thesis is dedicated to the elders of my family who are no longer with us.*
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Glossary of terms developed from the research conducted

7 Common Characteristics (CC) of design thinking:

Drivers – The external factors that kicked started a project; drivers kick started a project by either stimulating the identification of a problem or an opportunity.

Experts – The people from different disciplines who were involved with the project because their expertise was required to help generate suitable solutions to the problem.

Impact – The result of using design thinking to solve the problem identified.

Processes (CC) – The strategies, steps or processes developed or used to solve the problems given.

‘Design problems’, traditional or non-traditional – It described the nature of the problem identified.

Multidisciplinary – The disciplines which the experts belonged to.

Knowledge – Provided by experts to help generate the suitable solutions to the problems identified.

Design thinking’s Modes of Expressions (ME):

Graphicy – The ability to understand read and create still visual images other than words letters and numbers, as a means of communication (Baynes, 2013; Danos, 2011)

Language – Communicating using spoken and written words.

Numeracy – The ability to reason and apply numerical concepts.

Physicality – The physical characteristics of an object that can only be expressed in 3D.

Processes (ME) – A series of actions directed towards a specific aim.
Chapter 1 - Introduction
1.1. Introduction

According to Baynes (2013: 17), the management of design, the psychology of design and the systematisation of design into a bureaucratic process were the new interests developed in design research during the 1960s. This resulted in renewed interest in the area of design methods (ibid: 17). It was believed that if designers used suitable methods during the course of a particular piece of design work, the end result would be fit for purpose. It became apparent that designers relied on a distinctive mode of thought that was unique to the profession. An early example that supported this perspective was Lawson’s study (1979: 59-68) on cognitive strategies in architectural design. From the study Lawson discovered that given the same problem, fifth year architectural students used a solution focused problem solving strategy; whereas, fifth year science students opted for a problem focusing strategy. From this new perspective, Baynes (2013: 18) argued the need for further understanding as ‘designerly thinking’ could be the ability that allowed the use of models as a way of shaping the future.

It appeared that the term design thinking has yet to be fully understood. A 2012 conference (DTRS9 – Articulating Design Thinking at Northumbria University, UK) was established to address this issue (Rogers, 2012: 1-8). The understanding of the meaning of design thinking is still evolving, and it has found different forms of expression, thereby reflecting both its internal (or cognitive) aspects and its external characteristics and processes. Design thinking was being conceptualised as a form of situated cognition, but as a particular form of human thought, it is not yet fully defined or understood.

This thesis addressed the question of where have we got to in our understanding of design thinking? Where different authors offered interpretations and descriptions of design thinking, these had been referred to as definitions, although this might on occasions risk over-stating the authors’ intentions – they were steps along the road. This thesis brought these published conceptions of design thinking together with current ideas expressed by academics and practitioners through online
surveys, interviews and case study analysis to work towards a qualitative data driven model of design thinking as it is currently understood. It then articulated the differences in the understanding and use of the term.

This thesis provides an overview of the current understanding of the term design thinking. Early writers seemingly referred to aspects of design thinking by different names such as cognitive modelling, creative thinking, designerly ways of knowing and designerly thinking. It was important to understand their relationships with ‘design thinking’; doing so can shed light on its origins therefore allowing a more comprehensive understanding of the term. With ‘design thinking’ being such a complex term, the early stages of the thesis attempted to capture some of the complexity of this starting position.

The research employed a multi-method triangulation approach that allowed the researcher to use the most suitable data collection methods at any given situation (Plowright, 2011: 7). Each research question was addressed with this approach. In addition to being flexible, this approach facilitated reliability as the data gathered was cross examined throughout the research. With this research approach in mind, a three phase research model is developed for the data gathering. The first phase was an initial literature review, and the second phase being the main study. Data gathering for the main study was conducted via the mixed method research instrument that was developed from the findings of the literature review. It was designed to trigger participants into thinking about their views on design thinking. The findings from the research instrument were triangulated by case study analysis. They were then used to develop the qualitative data driven model of design thinking. Finally, the third phase of the research comprised validation studies conducted with academics and practitioners to validate the research methods, perspectives of academics and practitioners; and the qualitative data driven model of design thinking developed from the findings of interviews, online survey responses and case study analyses.
1.2. **Research background**

2009 saw the publication of a number of books exploring design thinking written by design practitioners and management consultants. It could be said these publications provided evidence of the growth in interest for design thinking. Some of them claimed design thinking as a process that guarantees innovation and, therefore, employing it could provide a competitive advantage (Berger, 2009; Brown, 2009; Brown and Martin, 2015: 56-64; Kolko, 2015: 68-72; Lockwood, 2010; Martin, 2009). As a result of these claims and perhaps the lack of understanding of the origins of design thinking, ‘new’ definitions for the term such as the following were created by design practitioners and management consultants:

‘The term design thinking is generally referred to as applying a designer’s sensibility and methods to problem solving no matter what the problem is. It is not a substitute for professional design or the art and craft of designing, but rather a methodology for innovation and enablement.’ (Lockwood, 2010: xi)

With these ‘new’ definitions, design thinking seems to be described as a process that generates innovation.

Burdick commented on these ‘new’ definitions of design thinking:

‘The term “Design Thinking” originated in an academic context from research into the cognition peculiar to designers. In the commercial world, it has become an easily branded turn phrase that designers have been quick to use to place themselves at the center of the innovation trend.’ (2009)

This led to Norman, the former Vice President of Apple (2010) branding design thinking ‘a useful myth’. From Norman’s viewpoint, design thinking is not restricted to designers; the article stated artists, engineers and scientists as examples of those who can employ it. As a result Norman (ibid) claimed design thinking was a PR term for creative thinking. Norman’s remarks have added further confusion to the terminology as the statement gave the view that creative thinking and design thinking were the same. It
could be argued that Norman’s viewpoint originated from published case studies of successful applications that were rarely backed up by any evidence or theory.

Nussbaum, Professor of Innovation and Design at Parsons School of Design and a design commentator, wrote an article (2011) on Fast Company’s website calling design thinking ‘a failed experiment’ as it had not produced the cultural change in business that design consultancies had hoped for. The reason behind this viewpoint was that design thinking had become a linear process in the business environment and, as a result, the potential creativity and perhaps the quality of innovation it could have offered were lowered. Having claimed that design thinking was a failure, Nussbaum proposed the concept of ‘creative intelligence (CQ)’ as a conceptual framework for measuring creativity. Nussbaum claimed the CQ framework was to be a way of measuring the ability of framing problems in new ways and solving problems.

Despite those views, design thinking was the cover and feature story of Harvard Business Review’s September 2015 issue. The feature and coverage given by the publication suggested the interest in design thinking remains.

The comments from Norman and Nussbaum implied both failed to give a clear definition of what creativity is before linking the terms (creative thinking and design thinking) together. While exploring creativity in education, Spendlove described an issue regarding the usage of creativity:

‘The term creativity has often been overused, oversimplified and misrepresented and frequently interchanged inappropriately for related terms such as enterprise, innovation or difference.’ (2005: 10)

In addition, Sternberg (1996: 678) pointed out that creativity was a topic that is widely spread in different domains at individual and societal levels, with the definition of creativity still being an on-going debate (1996: 283). Putting a term that is already complex on its own together with another that has multiple definitions has the potential to cause further confusion. With
the confusion over design thinking and its meaning, it is necessary to identify the origins of design thinking in order to provide the basis for understanding of this and other related terms.

In order to clarify if academic and practitioner understanding of design thinking are different to each other, the definitions of the term in the two contexts must be examined. Examining the two sets of perspectives and articulating their relationship could help to bridge the possible knowledge gaps that exist between them. The theories could also provide further evidence to support practitioner viewpoints of design thinking. Doing so could lead to a more complete model of design thinking using knowledge from both perspectives. Having such a model could help those who wish to employ design thinking to gain a deeper understanding of the term. In addition the research could also answer the question of whether design thinking represents a marketing opportunity or a tool to add value to the services that are offered by leading business, design and management consultancies around the world.
1.3. **Aims and objectives**

1.3.1. **Research aims**

The aim of this research is to identify the possible knowledge gap that exists between academic and practitioner understanding and application of design thinking to generate a consensus-driven definition.

1.3.2. **Research objectives**

*Objective 1:*  
Articulate the meanings and understanding of design thinking since the 1960s

*Objective 2:*  
Clarify if design thinking is thinking done by designers.

*Objective 3:*  
Explore the relationship between academic and practitioner application and understanding of design thinking.
1.4. Research questions

1.4.1. Research questions (RQ) for objective 1 (Articulate the meanings and understanding of design thinking since the 1960s.)

1. Where was the concept of design thinking first articulated?
2. Has the meaning of design thinking changed since the 1960s?
3. Do academic and practitioner interpret design thinking differently?
4. Can a ‘generic’ design thinking mode be created from academic and practitioner interpretations?

1.4.2. Research questions for objective 2 (Clarify if design thinking is thinking done by designers)

5. How is design thinking expressed?
6. Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?
7. Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?

1.4.3. Research questions for objective 3 (Explore the relationship between academic and practitioner application and understanding of design thinking.)

8. Does design thinking as incorporated in designing within academia match academic articulation of the concept?
9. Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?
1.5. **Scope of Research**

This PhD research focused on articulating and defining design thinking within the field of design through investigating the understanding of the term and its application within academia and practice. It should be noted that the investigation focused on industrial and product design, graphic design and service design as the main design areas. With design having a long history, the 1960s has been selected as a starting point when conducting the literature review. This was because the 1960s was the time when scholars with associated publications began to review the nature of designing as a subject and it could be where the influence of current thinking might appear.

The literature review was conducted to articulate meanings and understanding of design thinking since the 1960s. It explored terminologies that are possibly related to design thinking. This strategy provided data on the origin, ownership and meanings of the terminologies; therefore, creating a background to the picture of the current understanding of design thinking held by academics and practitioners.

To clarify the meaning of design thinking and explore whether design thinking is thinking done by designers, a point of departure was provided by the initial literature review. From this starting point, a range of data was collected. A research instrument was designed to incorporate the following methods: focus groups, interviews, online survey and seminar (focus group interviews). The mixture of methods allows the researcher to maximise the chance of gathering quality data within a variety of sources. The research instrument was housed on a website, which allowed participants from around the world to take part. The research website was also advertised on selected online platforms, mainly industrial and product design professional bodies and design academic forums. Before using the research instrument to conduct the main study, a pilot study was undertaken. All methods were tested. The pilot studies identified online survey and semi-structured interviews being the as most efficient methods in terms of the quality of data and resources required (time, research budget and participants). As a result of the findings from the pilot studies, focus groups and seminars (focus group interviews) were not taken forward into the main study. Reliability of the data was
achieved by using case study analysis examining its findings. It should be noted that the case studies selected were mainly in the industrial and product design domain. The domain was selected through opportunity sampling and theoretical sampling as the Loughborough Design School had well established links within the domain to provide suitable case studies. In addition to the sampling techniques, industrial and product design was also the area in which the researcher conducted their higher education in and had most experience of. The findings from the research instrument and case study analysis were then used to identify and develop the academic and practitioner consensus definitions of design thinking, identify design thinking’s modes of expression and develop the qualitative data driven theory of design thinking. The consensus definitions, modes of expressions along with the model and its empirical foundations were validated through validation studies conducted with experts from academia and practice. It is important to note that despite the intention of this PhD research being an investigation of design thinking, the research conducted was not intended to explore design thinking from a cognitive psychology viewpoint.
1.6. Thesis structure

This thesis contains the following chapters:

Chapter 2 – Literature review

The literature review explored the definitions, origins and ownership of the term design thinking and four other related terms. In addition, the literature review also investigated the current usage and understanding of the term by non-designers such as management consultants. By investigating the usage and understanding from the non-design sectors, the different perspectives between design academia, design practice and non-design sectors could be mapped therefore creating a background to the picture of the current understanding.

Chapter 3 – Research methodology

This Chapter explored and justified the methodological stance, research methods, sampling techniques and data collection method selected. The Chapter also presented the multi-methods research instrument design and justified the design decisions behind it.

Chapter 4 – Pilot studies and updated mixed-method research instrument

This Chapter presented the pilot studies and their findings. It also described the updates that were brought into the research instrument from the feedback gathered during the pilot study.

Chapter 5 – Main study

The data for the main study was collected by online survey and interviews. The data collected was analysed by content analysis. From the analysis additional common characteristics of design thinking were identified. In addition, thematic analysis conducted on the data developed the academic and practitioner consensus definitions of design thinking and identified the differences in their perspectives. The Chapter also presented findings regarding how design thinking is expressed and mapped them according to the common characteristics.
Chapter 6 – Case study analysis

Six case studies were selected for analysis. Three were from academia; in the form of final year student design projects and three were from professional practice (two product design and one service design). The case study analysis conducted was the third aspect of triangulation and its purpose was to check the reliability of the data.

Chapter 7 – A qualitative data driven theory of design thinking

This Chapter presented the qualitative data driven model of design thinking developed from the findings of the main study and case study analysis.

Chapter 8 – Evaluation study

The Chapter presented the evaluation study conducted with academics and practitioners to validate the findings of the research. It also presents the feedback given by the participants.

Chapter 9 – Discussion

The discussion explored the extent to which the aims and objectives were achieved, and the research questions addressed as well as analysing the findings in relation to other works on design thinking’s common characteristics, modes of expressions and potential application sequence. It also discussed the feedback from the evaluation study.

Chapter 10 – Conclusions and future work

This chapter presented the conclusion of the research. It presented the research’s contribution to knowledge and the potential areas of future work that could be carried out.

Figure 1 provides an overview of the structure of the thesis. Each Chapter is colour coded to help the reader keep track of progress.
Figure 1 Thesis structure diagram
2.1. Literature review introduction

Norman, a well-known design practitioner and author made the following comment regarding design thinking in 2010:

‘Design Thinking is a public relations term for good, old fashioned creative thinking.’ (Norman, 2010)

This was the response given to the increased attention and interest given to design thinking. Norman (2010) branded design thinking ‘a useful myth’ and it is understandable to call it a myth since the case studies from the design industry are very rarely backed by theory. An example of this could be the Shimano bicycle project (Brown, 2009: 13-15) that was presented in Brown’s book. According to Brown, working alongside IDEO’s designers enabled Shimano to create an innovation that brought cycling back to the communities of America. However, in the two pages that were dedicated to the ‘case study’, there was no mention of the process and theory of design thinking with the exception of the phrase ‘human-centred exploration’ (ibid: 14). Another design project that supported Norman’s claims was Frog Design’s Lufthansa airline branding project (Esslinger, 2009: 74-75). The presentation of the project was similar to Brown’s in that it outlined the goals that Lufthansa were hoping for, the people that were involved, some details of the design activities that were carried out; but with little information on the processes used. The only theoretical emphasis presented was the need to embrace the goals of the business partner.

In addition, attempts from design commentators and management consultants like Berger (2009: 302), Martin (2009: 62), Nussbaum (2011), Walters (2011) at defining the term have added to the confusion and failed to remove the myth associated with the terminology. These attempts at defining design thinking only provided a glimpse of the recent developments of the term’s meanings and failed to look deeper into the origins and history behind the term. Examining Norman’s statement, the definition of design thinking depends on the meaning of creative thinking from his viewpoint. In reality, such statements risk adding further confusion to terms that are already complex and ill-defined.
With the interests surrounding design thinking, identifying the origins of the term and clarifying if academic and practitioner theories of design thinking are different could provide answers towards producing a definition for design thinking. The definition could clarify if design thinking is just a marketing tool that is employed by some leading design consultancies around the world and articulate the understanding of design thinking.

2.2. Definition, origin and ownership of terms

In this section the definition, origin and ownership of the following terms that are related to design thinking will be explored:

- Design thinking
- Cognitive modelling
- Creative thinking
- Designerly ways of knowing
- Designerly thinking

In terms of strategy, the literature review began with a review of the most recent design thinking publication (published during or after 2009) written by academics and practitioners (Baynes, 2013; Berger, 2009; Brown, 2009; Cross, 2011; Esslinger, 2009; Lockwood, 2010; Martin, 2009 and Nussbaum, 2011 for example). Doing so allowed the latest viewpoints and development on design thinking to be articulated. These publications also provide opportunities to identify the different concepts within design thinking. The identification of these different concepts within design thinking formed the next step in the literature review. Upon the advice of the researcher’s PhD’ supervisors the literature review began tracing the origins of these concepts within academic publications from the 1960s. The 1960s was set at the boundary of the literature review as it was the decade when researcher began to explore design as a discipline; therefore, making it a suitable place to begin or stop. There was an exception however, where the boundary of 1960 was broken. The exception was the review of C.S Pierce’s methodology of science; to gain a comprehensive understanding of the
concepts it was necessary to refer the original publications that were published in the 1860s. The final step of the literature review was to identify the potential differences between academic and practitioner views on design thinking, therefore, articulating the meaning behind the definitions, origins and ownership of design thinking and the related terms.

2.2.1. What is design thinking?

Design thinking was a term that emerged from the design methods movement dating back to the 60s when design researchers started to define the nature of design.

Archer acknowledged that cognitive modelling plays an important part in making design activity different to science and other scholarly activity when he wrote:

‘(...) examining the proposition that the way designers (and everybody else for that matter) form images in their mind’s eye, manipulating and evaluating ideas before, during and after externalising them, constitutes a cognitive system comparable with but different from, the verbal language system (...) human beings have an innate capacity for cognitive modelling, and its expression through sketching, drawing, construction, acting out and so on (...) Thus design activity is not only a distinctive process, comparable with but different from scientific and scholarly processes, but also operates through a medium, called modelling...’ (Archer, 1979a: 18)

Lawson (1980) provided empirical evidence of the existence of a different mode of thought being employed through studies that he ran on design behaviour. His experimental goal was to understand how designers (architects) perceived the relations between variables in multidimensional design problems and how they produced desired relations between the elements of their solutions. The subjects of the experiments were fifth year science and architecture students who were given four pairs of coloured blocks for the study. The task given was to arrange four blocks under the following rules: take one from each pair to cover all twelve
squares with no blocks projecting, the black or white surfaces must be facing upwards and the vertical sides must have the maximum amount of blue or red surfaces displayed.

From the experiment, Lawson was able to use the data to identify the different strategies that were employed by the scientists and architects. The scientists opted for a problem-focused strategy with their results showing them centred on the structure of the problem and finding the solution by discovering the structure of the problems. However, the architects opted for a solution-focused strategy with ‘high scoring’ solutions being constantly made and solutions continued to be produced until the desired solution was created and chosen.

Lawson identified that the training which the subjects received from their courses in higher education could be a factor in their choice of problem solving strategy. With designers and architects, both professions are taught mainly by example and practice. A designer or architect’s evaluation of performance is based on the solution provided rather than the methods of reaching it. Lawson linked his work to Rittel and Webber’s (1973) theory of design problems being ‘ill-defined, ill structured, or “wicked”, therefore forcing design practitioners to adapt to a solution-focused problem solving strategy as it is the most suitable way to deal with incomplete information from these ‘wicked’ problems. From his experiments, Lawson concluded that a new methodology that is specific to designers would evolve:

‘(...) a methodology which does not depend on the completion of problem analysis before synthesis can begin.’ (Lawson, 1979: 68)

This could be seen as the beginning or the recognition of design thinking. Lawson acknowledged the possibility of design being different from science and, therefore, having its own mode of thought. However, he did not give the idea a name.

Cross built on work from Archer, Lawson and Rittel and Webber when he wrote:
‘(...) that design problems are ill-defined, ill-structured, or ‘wicked’ (Rittel and Webber 1973). They are not the same as the ‘puzzles’ that scientists, mathematicians and other scholars set themselves. They are not problems for which all necessary information is, or ever can be, available to a problem-solver. They are therefore not susceptible to exhaustive analysis, and there can never be a guarantee that “correct” solutions can be found for them. In this context a solution focused strategy is clearly preferable to a problem-focused one... the designer’s task is to produce “the solution”...’

‘In order to cope with ill-defined problems, the designer has to learn to have the self-confidence to define, redefine and change the problem-as-given in the light of the solution that emerges from his mind and hand.’ (Cross, 1982: 224)

Examining Cross’ description of design thinking, he brought together all the concepts that were raised from the late 60s to early 80s. In addition to bringing the concepts together, in last sentence of the description Cross appeared to have highlighted the concept of abductive reasoning, a concept that was put forward by Peirce in the 1860s (Burch, 2010).

One of the most important theories that Peirce presented was integrating abduction, deduction and induction as the three phases of the methodology of science as it was then understood.

In this theory, abduction was the first phase of science methods as the phenomenon presented could be surprising or puzzling. In order to move forward, the surprise phenomenon must be explained. If the provisional adoptive hypothesis explaining the surprise phenomenon was correct then the science method moved into deduction, the second phase of the science methodology. The purpose of this phase was to find out the facts that were needed for the surprise phenomena to be true. The final phase was induction where experiments were performed to test if the provisional adoptive hypothesis fitted along with the theory or facts that were discovered in the deduction phase.
Looking further into Peirce’s theory, March (1976: 270) argued the core logic of the design process required solutions to be produced differently. March’s P-D-I model appeared to be a revised version of Peirce’s methodology of science. Roozenburg summarised the model:

‘March outlined a rational design process consisting of ‘(1) the creation of a novel composition, which is accomplished by productive reasoning, (2) the prediction of performance characteristics, which is accomplished by deduction; and (3) the accumulation of habitual notions and established values, an evolving typology, which is accomplished by induction.’

(Roozenburg, 1991: 216)

From looking at these models and the evolution of the definition, there was strong evidence suggesting that abductive reasoning is a vital part of design thinking. It would be reasonable to say that without abductive reasoning it would not be possible for design to happen as Roozenburg (1993: 17) commented abductive reasoning as being the necessary logic of design – the necessary step from function to form.

From Archer, Cross, Lawson, March, Rittel, Roozenburg and Webber’s work design thinking can be said to have the following characteristics:

- Abductive reasoning is a vital part of design thinking (Lawson, 1979; Roozenburg, 1993).
- Design thinking is a way to resolve ill-defined problems (Cross, 1982 & 1990; Rittel & Webber, 1973)
- Design has its own unique way of problem solving different to humanities and science (Archer, 1979b; Lawson 1979, Cross 1982 & 1990)

Since 2008, the interest in design thinking from non-design sectors led to the creation of new descriptions. Here, non-design sector means organisations or people that do not employ design in their practice. Management consultants and consultancies, financial services, government are examples of the non-design sectors. Several factors could
be the trigger of interest from the non-design sectors in employing design thinking into their operations as a result of their belief that there could be a commercial advantage from using the process.

The most noticeable claim of applying design thinking into a company identified by Martin, a former management consultant and Dean of Rotman School of Management (2009: 147-150) was the rise of Apple under the leadership of CEO Steve Jobs. Jobs returned to Apple in 1997 when the company was struggling against its rivals. Under his leadership the company designed and produced some of the most iconic products that are integrated into people’s daily life. Fifteen years after his return to the Company, Apple became the most valuable company in the world with its market capitalisation worth more than 500 million USD (Burrow and Satariano, 2012).

An example of the Company applying design thinking successfully could be the iPod and its user experience. The product was launched in October 2001 and it changed the user experience of portable music players. In January 2001, nine months before the iPod was launched, the company introduced the iTunes digital music junk box software to the market (Peptitone & Goldman, 2013). The software allows its users to manage and convert their music into MP3 format or AAC (Apple’s music format for the iPod). The iTunes program effectively became the music centre on many users’ computers (ibid). In 2003, the iTunes online music store was launched and it allowed users to buy their music online and directly download it to their computers then onto the iPods. (Apple, 2012) Once the iTunes store was launched the iPod steadily drove its competition away from the market. The user experience was one of the key unique selling points (USPs) that allowed the iPod to dominate the market. In the early 2000s converting music into MP3 format was a long winded process as the software that was supplied with MP3 players was complex and hard to navigate. However, iTunes allowed the user to convert their music in a few simple steps with a fluid and simple interface. In addition to the software itself, having iTunes also allowed users access to the iTunes store where they can browse and buy music with the click of a button.
Combining these two factors together Apple managed to build a user experience that was unrivalled at the time and started the digital music market revolution. Applying design thinking seemingly allowed Apple to identify the gap in the portable music player’s market. Exploiting that market gap allowed the company to innovate and create a new user experience and changed the market. (Esslinger, 2009: 148)

Looking at the iPod example, it suggested that Apple wanted to create a more engaging, focused and holistic user experience for the portable music player. The competitions’ management software for their MP3 players focused on the function of converting music file formats and had little thought regarding the users’ experience, whereas, the iTunes was designed to be the product’s user interface on the computer. It provides users with a continuation of the iPod experience on their computers hence creating a ‘complete’ experience. Where Apple succeeded and others failed back in the early 2000s was the company’s ability to create a different musical experience in the portable music player market (Brown, 2009: 163-164). The iPod was part of the reason that Apple became the world’s largest company by market value in 2012 (Nussbaum, 2013: 188) and as a result, many from the non-design sectors believed embedding design thinking could be the next tool to help them gain an advantage over their competitors. In addition to Apple, Research in Motion (RIM) and Procter and Gamble (P&G) (Martin, 2009: 62-73 and 88-103) were also seen as large organisations that had applied design thinking within their organisations.

Alongside successful applications of design thinking, the design projects discussed by Brown (2009) and Esslinger (2009) may have contributed towards the increased interest in design thinking from the non-design sectors. It could be seen that both used their publications to communicate the essential elements of design thinking to a non-design audience. To show design thinking’s broad range of application contexts, Brown (2009: 247) used the projects from business, innovation and design as examples. Some of Brown’s project examples included Mr Clean Magic Reach for P&G, a multifunctional house cleaning tool (2009:}
24-25), a bank customer service strategy for Juniper Financial (2009: 53-54) and Future Vision for HBO; a research study for HBO delivering content on the Internet and other mobile platforms (2009: 100–102). Esslinger’s publication was also similar in the sense of using design projects to showcase the potential value of design for business. However, in Esslinger’s publication (2009) the emphasis on design thinking was much less than Brown’s.

In addition, business writers such as Martin (2009), Nussbaum (2011 and 2013) and Verganti (2009) also brought attention to the topic with their work.

In 2010, at the 8th Design Thinking Research Symposium (2010: 99-105), Cross revisited some major features that are embedded in design thinking through a conference paper. The paper indicated that the core academic definition of design thinking has not changed since the concept originated from the late 60s:

‘Recent extensions of the concept of design thinking have the potential to undermine the core concept of ‘designerly ways of knowing’ and therefore of the concept of design thinking itself.’ (2010: 99)

However, looking at it from a design practitioner’s perspective, the meaning has changed because of the contexts in which design practitioners work. Dorst, a design academic (2011) commented that the increased interest in design thinking was caused by the design industry evolving. As part of the evolution some of the activities and processes were professionalised thereby allowing them to be applied in other disciplines or fields.

However, Roozenburg (2010: 39-49) was concerned by what he called the ‘new’ design thinking movement, leading him to question if the process was on its way to becoming meaningless. According to Roozenburg, the ‘new’ design thinking movement promoted design thinking as an ‘interdisciplinary and innovative strategy’ (2010: 39). The main problem from this viewpoint was the lack of understanding of the origins and
acknowledgement of the cognitive processes that design thinking derived from and what academic design research stands for.

Here are a selection of examples of these ‘new’ descriptions of design thinking used by practitioners from both design and non-design sectors.

Tim Brown, CEO of design consultancy IDEO, described design thinking as a powerful innovation approach that can be used by anyone to create breakthrough ideas (2009: 3). A range of design projects were also used to further illustrate the description given.

The design projects discussed by Brown were attractive for the non-design sectors as they showcased successes from using design thinking as a way of creating products and services. Reviewing the Shimano project (see Chapter 2.2; page 15), it could be said IDEO’s team used abductive reasoning to reframe and redefine the brief allowing greater flexibility during the research phase to explore the problem in a wider context. As a result of identifying a wider research area, the project became multidisciplinary. Brown claimed the application of design thinking enabled Shimano to achieve better than expect results. It could be argued that Brown’s emphasis on design thinking enabling practitioners from different fields to work together was recognition towards cognitive modelling as it is one of the main drivers within design thinking.

Throughout Brown’s book, the projects used as design thinking application examples were described in a similar format to the Shimano one: presenting the problem given, methods used and personnel involved and end result. Further review of the projects or the concepts behind Brown’s description of design thinking identified there was little information and theory to support the processes presented in the text. It appeared that Brown presented design thinking in simple language with a heavy emphasis on the activities and processes conducted during the application of design thinking. Furthermore it also emphasised on design thinking’s possible application contexts.
The non-design sector has also attempted to create ‘new’ descriptions of design thinking. Roger Martin, the Dean of Rotman School of Management, University of Toronto wrote:

‘The design thinker therefore enables the organization to balance exploration and exploitation, invention of business and administration of business, and originality and mastery. Design thinking powers the design of business, the directed movement of a business through the knowledge funnel from mystery to heuristic to algorithm and then the utilization of the resulting efficiencies to tackle the next mystery and the next and the next. The velocity of movement through the knowledge funnel, powered by design thinking, is the most powerful formula for competitive advantage in the twenty-first century.’ (Martin, 2009: 26)

Martin’s description of design thinking focused on the business side even more than Brown’s. Martin (2009) used case studies of successful managers to show how their companies functioned. However, there was little mention of design practitioners in the design projects subsequently presented: Blackberry smartphones by Research in Motion (Martin, 2009: 51-78) and Proctor and Gamble (P&G) company’s direction change (Martin, 2009: 79-103). The description gave an impression that the author was trying to make the terminology exclusive to business practitioners and phasing out the designers. A summary of his book written by Kimbell pointed out Martin’s lack of focus on the cognitive aspects of design thinking:

‘Martin focuses on methods used by successful managers he interviewed and examines how firms as a whole function. His vision of design thinking deals less with individual cognitive styles and doesn’t present sets of material practices; rather, he focuses on systems of organizations.’ (Kimbell, 2011)

Above are some notable ‘new’ descriptions of the terminology. These ‘new’ descriptions from design and non-design sectors have added an extra layer through perhaps the lack of understanding of the original definition.
This extra layer created a renewed interest in the process. However, it seemed to have caused further confusion on what design thinking is, leading to an apparent lack of belief towards design thinking. From the literature reviewed, design thinking was a term that originated from the design methods movement in the late 60s, later on being formulated by the likes of Archer, Baynes, Cross, Dorst, Lawson, Roberts and Roozenburg. Evidence suggested that ownership of the term ‘design thinking’ belongs to the design sector (design academics and practitioners).

2.2.2. Cognitive modelling

From the literature in the 1970s (Archer, 1979a; 1979b; Lawson, 1979) cognitive modelling was a term often linked with design thinking. As the term has been linked to design thinking, their relationship needed to be explored.

Archer was developing a theoretical framework to relate the term ‘cognitive modelling’ to design activity, design research and education. In an internal paper from the Royal College of Art’s Design Education Unit the nature and status of cognitive modelling within design activity was addressed:

‘The conduct of design activity is made possible by the existence in man of a distinctive capacity of mind, analogous with the language capacity and the mathematical capacity. This is the capacity for cognitive modelling.’ (Archer and Roberts 1992: 4)

Archer and Roberts indicated that the capacity to design is a fundamental human trait and the difference between a professional designer and a non-designer such as an accountant could be how cognitive modelling is being employed.

Before exploring the relationship between cognitive modelling and design activity, the term ‘design activity’ must be defined. Luckman defined design as the following:
‘The process of design is the translation of information in the form of requirements, constraints and experience into potential solutions which are considered by the designer to meet required performance characteristics.’ (1967: 84)

The Royal College of Art (RCA) defined design activity as:

‘Design activity is the exercise of the set of skills useful in planning, making and evaluating.’ (1976)

Jones (1992: 4) defined design activity as initiating change in man-made things. Examining the definitions of design activity, the role of cognitive modelling within design activity can be identified. Using Luckman’s (1967: 84) definition for example, it stated that designing is the translation of different information into solutions by designers; the need to translate different information showed that design required cognitive modelling. The first two parts of design activity are ‘planning and making’ in which cognitive modelling allows designers to conceptualise and create products, systems or services in their mind from the moment a design brief is presented.

An example of the progression in the exploration of the relationship between design activity and cognitive modelling was experiment such as Lawson’s (1979: 209-220) *Cognitive Strategies in Architectural Design*. Archer looked at the meaning of the terminology again within the design context:

‘The expression “cognitive modelling” is intended to refer to the basic process by which the human mind construes sense experience to build a coherent conception of external reality and constructs further conceptions of memory and imagination.’

‘The expression ‘imaging’ is referred to the part of cognitive modelling which construes sense data and constructs representations spatially and presentationally, rather than discursively and sequentially.’ (Archer, 1992a: 6)
Cognitive modelling represents an essential part of design activity, as how a designer thinks relies on cognitive modelling. With design problems often labelled as being ‘ill-defined’ problems (Cross, 1982: 224 and 1990: 127) there is no certain route for solving the problems. In order to achieve a desired outcome from given brief, designers often have to use past experiences to form concepts and possible solutions. Archer (1979a: 17-18) commented that everyone can design to some extent, our unique mind and its capacity made design activity possible. Therefore, we must look at the term from an evolutionary and human psychology context. Pinker (1997) stated that every human is capable of cognitive modelling:

‘The manipulation [used by people] can be novel because human knowledge is not just couched in concrete instructions like ‘How to catch a rabbit’. Humans always analyse the world using intuitive theories [models] of objects, forces, paths, places, manners, states, substances, hidden biochemical essences, and, for other animals and people, beliefs and desires. People compose new knowledge and plans by mentally playing out combinational interactions between these laws in their mind’s eye.’ (Pinker, 1997: 188)

Pinker acknowledged the power of imagination and the capability of cognitive modelling makes us unique in the animal world. As design activity solves ‘ill-defined’ problems lacking the power of imagination and cognitive modelling would make design activity impossible.

Baynes (2009a: 17-18) summed up Pinker’s comments:

‘The key point is that humans achieve their goals by complex chains of behaviour, assembled on the spot and tailored to the situation. People can react inventively and engage in radically different behaviours “on the spot.” They plan their behaviour using cognitive models of the causal structure of the world.’

From Baynes’ statement, the relationship of cognitive modelling and design activity appeared to become clearer. Page (1966) defined design as ‘the imaginative jump from present facts to future possibilities.’
Design activity is complex and enables humans to solve problems. In order to achieve a desired outcome or the goal, those who take part in design activities must adapt their approach to the problem or situation by using cognitive modelling.

A project that demonstrated Page’s statement in action would be The King’s Fund Bed project (Baynes, 2009b: 15-20) which was completed for the NHS in the 1960s led by Archer’s multi-disciplinary team at the Royal College of Art. Baynes wrote (2013: 64). The aim of the project was the following:

‘The aim of the bed project was not only to develop a national specification for a health service but also to use this ‘real’ design project to throw light on the nature of design and designing.’ (ibid: 64)

The working prototype for the hospital bed was produced by a team that included an industrial designer, an aeronautical engineer, a mechanical draughtsman, a sheet metal craftsman and a welder. The team used their cognitive modelling abilities to turn a written specification into a physical product.

Cognitive modelling is a vital part of any design activity. Improved understanding of its role has enabled the design field to better understand the process of design activities. However, it would be wrong to apply the term exclusively to the design sector because every human has the ability of cognitive modelling. Looking at the work of Archer, Baynes and Roberts it would be reasonable to assume that designers might have unlocked the ability of cognitive modelling to a higher level than others. As cognitive modelling is an ability that is unique to humans, the terminology’s ownership belongs to the biology and psychology field.

2.2.3. Creative thinking

With a mixture of perspectives regarding creativity's relationship with design thinking, the term must be defined and examined.
The aim of this section is to define creative thinking in the context of design. According to Candy (1998: 112) creativity had been defined by many different aspects and contexts; as a result, a fully coherent model of its multi-dimensional aspects has yet to be achieved. For example, according to Boden creativity is:

‘the ability to come up with ideas or artefacts that are new, surprising and valuable. ‘Ideas’ here include concepts, poems, musical composition, scientific theories, cookery recipes, choreography, jokes – and so on.’ (2004: 1)

Boden’s definition for creativity was an example that demonstrated the broad aspects of human behaviour to which creativity can be applied and the complexity of the term. Another example that described the broad aspects and complexity of creativity was given by Partridge and Rowe:

‘Creativity’ is an evocative, emotion-charged word that can mean very different things to different people.’ (1994: 1)

Partridge et al (1994: 7) stated that any specific definitions naturally contain an implicit bias towards a certain theory; as a result, giving a fixed definition of creativity was perhaps misguided. To further establish the broad spectrum within which creativity had been defined by Partridge et al (1994: 7) additional examples of definitions for creativity were needed. Rindlay and Lumsden’s (1988: 10) definition was an example that demonstrated that:

‘We define discovery as the product of the creative process. Thus, a discovery may be the articulation of a new problem, a solution to a pre-existing problem, or both. An innovation is any discovery that attains some level of adoption in the society under consideration.’

Creativity is a term that is complex with different aspects of application within different contexts. This had highlighted the potential issues of linking two complex terms such as creative thinking and design thinking together. Without understanding the meanings of the terms, linking to two could lead to further confusion.
To understand and identify any possible links between creative thinking and design thinking, the works of Spendlove and Sternburg were selected. Spendlove’s research in the development of both policy and practice in a variety of areas including design and technology education, teacher development and creative education (The University of Manchester, 2012) made Spendlove’s definition of creativity the most relatable to the context of this thesis and on the topic of design thinking. With one of the research’s objectives set to clarify if design thinking is thinking done by designers; the contexts of which Spendlove’s definitions emerged appeared to be a suitable starting point to explore the linkage between the two terms.

Sternburg’s work was selected because some of Spendlove’s research was based on the theories that were put forward by Sternburg in the 1990s. It had been acknowledged that selecting two specific researchers’ work could lead to bias towards certain theories. However, with the meaning of creativity being different in different contexts; selecting work from researchers within the field of this thesis was the only way to truly understand creative thinking and design thinking relationship.

Sternburg put forward the following definition for creativity:

‘Creativity is the ability to produce work that is both novel (i.e., original or unexpected) and appropriate (i.e., useful or meets task constraints)’

‘At an individual level, creativity is relevant, for example, when solving problems on the job and in daily life. At a social level, creativity can lead to new scientific findings, new movements in art, new inventions, and new social programs.’ (Sternburg, 1996)

Looking at Sternburg’s definition of creativity it fits into the design context well; as design has the power to shape the future, the social part of the definition reflects the importance of creativity in design. Furthermore Sternburg’s (1993: 229-230) investment theory of creativity identified six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. These six distinctive
characteristics can be related to how design activities achieve their goals. To identify if the investment theory is a suitable definition of creativity in the design context a content analysis of literature published in 2013 was conducted. Nussbaum’s (2013) book *Creative Intelligence* (CQ) was chosen. The reason behind using this book was the author’s claims regarding design thinking and creativity. The content analysis compared the investment theory’s six resources of creativity to the CQ framework’s five competencies.

The literature evidence showed Sternburg’s investment theory and Nussbaum’s ‘CQ’ framework had some similarities. The CQ framework has five ‘competencies’, they are: knowledge mining, framing, playing, making and pivoting (Nussbaum, 2013: 33–39); this is similar to the six resources for creativity. Comparing the listed characteristics and meaning behind them, Tables 1 presents their similarities:
<table>
<thead>
<tr>
<th>Competencies/ Resources</th>
<th>Evidence from the CQ framework</th>
<th>Evidence from the Investment theory</th>
<th>Similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and knowledge mining</td>
<td>Nussbaum (2013: 33) claimed that knowledge mining is the knowledge at the foundation of the CQ framework; here, it means bringing together information from various sources in new and surprising ways.</td>
<td>According to Sternburg (1993: 229), knowledge from the six resources of creativity is the must have requirement in order for someone to contribute creatively.</td>
<td>Both form the foundation for the different theory or framework. Both authors emphasised without in depth knowledge of the field, one cannot make a meaningful contribution towards creativity.</td>
</tr>
<tr>
<td>Framing and thinking style</td>
<td>Framing is the focal lens that can guide us through the vagaries of a volatile world. People who understand framing techniques are better able to shift their perspectives depending on the situation, environment, and the community they’re interacting with (Nussbaum, 2013: 34).</td>
<td>Thinking styles are the ways in which people choose to use their intelligence as well as their knowledge. Thus thinking style focuses on how these abilities and knowledge acquired are used in day-to-day interaction with the environment (Sternburg, 1993: 229).</td>
<td>Both authors described framing and thinking style as ways people interact with their environments and situations.</td>
</tr>
<tr>
<td>Pivoting and Personality</td>
<td>Pivoting from the inception to the production side of creation is the final of the five competencies. Pivoting is a way of reprising creativity’s crucial role in capitalism as a driver of innovation and growth. Pivoting often requires charisma, a relationship with the community of people invested in your project: team members, partners and a devoted audience (Nussbaum, 2013: 36-37).</td>
<td>Creative people seem to share certain personality attributes. The fifth and last attribute is belief in oneself. Because they go against vested interests, creative people often find themselves at points where no one seems to believe in their ideas except for themselves (Sternburg, 1993: 230).</td>
<td>Some aspects of pivoting and the fifth aspect of personality are similar in the sense that they are required in order to maintain the relationship within the creative teams.</td>
</tr>
</tbody>
</table>

Table 1 The similarities of the 5 Competencies of Creative Intelligence (CQ) and 6 Resources for Creativity
The evidence indicated that certain aspects of the investment theory were similar to the CQ framework. With these similarities it could be said that the investment theory is a useful way of defining creativity in the design contexts.

Spendlove (2005: 10) commented that creativity was being overused, oversimplified, misrepresented and frequently interchanged inappropriately for associated terms such as innovation or enterprise. It could be argued that the ‘CQ’ framework is an example of creativity being oversimplified and interlinked with associated terms. With this in mind, Spendlove (2008b: 11) went on to clarify and explain the definition of creativity in the design sector with the Triadic Schema (Figure 2). The basis of the Triadic Schema model is the concept of emotion residing in three areas in Design and Technology: the person, the process of learning and the products that surround them. In the centre of this model is the location where the three areas link to human emotions.

![Triadic Schema model](image)

Spendlove identified human emotions and feelings as being the main manipulators that have influence on the creative thinking process. This is important as one of the main functions of design activity is emotional
manipulation and designers are often seen as powerful ‘creators’, ‘propagators’, ‘changers’ and ‘enders’ (Spendlove, 2008b: 12). Understanding how human emotions affect thinking and behaviour is the key to truly understanding creative thinking in the design context.

With an understanding of the definition of creativity in the design context and Spendlove’s concepts of design activity, it is possible to describe the relationship between creative thinking and design thinking. From the viewpoint of those who conduct design activity, creative thinking could be seen as a component of design thinking. Without that, it would not be possible to carry out design thinking. From the viewpoint of the non-design sectors, creative thinking could be seen as a resulting outcome of conducting design thinking.

2.2.4. Designerly ways of knowing

The concept of designerly ways of knowing originated in the same period as design thinking. The term was first used in the 1980s from the series, ‘Design as a Discipline’ in the Design Studies journal. The term was introduced by Cross (1982: 221-227) who expanded on the concept of Design as the third area of education; a concept that was introduced by Archer (1979b: 18-20):

‘A third area in education could therefore legitimately claim technology and the fine performing and useful arts, although not their scientific knowledge base (if any) or their history, philosophy and criticism (if any), without treading on anyone else’s grass.’ (ibid: 19)

Before moving further, the difference between ‘knowing’ and ‘thinking’ within the design context must be addressed. In the context of design, ‘knowing’ is the knowledge or database which designers draw upon when they encounter a design problem as such. ‘Thinking’ is the cognitive process that designers employ to select the suitable method to tackle the design problem.
Archer’s concept of design as the third area in education was related to the RCA’s definition of design activity discussed in Chapter 2.2.2; design activity being a human area of competence. Design as the third area of education was the foundation that allowed designerly ways of knowing to develop. In order for design to be a discipline, Archer and Cross signalled the importance of design creating and using its own language rather than adjusting design to fit into other languages:

‘Another problem was that design theories were also often communicated in language that was alien. I do not mean that the wrong kinds of words were used I mean that words of mathematics or scientific notation alone were themselves inappropriate.’ (Archer, 1979a: 18)

Similarities of designerly ways of knowing and design thinking were identified from the literature evidence. Both are vital to how a design practitioner’s mind is shaped and how they work. However the final definitions of the terms are different. Designerly ways of knowing was a concept that was created when design academics sought to define design as a discipline. Therefore designerly ways of knowing is the framework or knowledge base that is used by designers to identify if a problem can be defined as a design problem. Designerly knowledge is knowledge that relates to configuration, composition, meaning, value and purpose in man-made phenomena (Archer, 1979b: 20). Designerly ways of knowing allows designers to choose the appropriate method to create solutions or solve the problems.

Adding on to Archer’s viewpoint, Cross (1982: 223) pointed out that design’s epistemology is different to science or humanities:

‘(…) there are things to know, ways of knowing them and ways of finding about them’ (Royal College of Art, 1979) that are specific to the design area. The authors believe that there are designerly ways of knowing, distinct from the more usually-recognized scientific and scholarly ways of knowing.’
‘Design must have its own inner coherence, in the ways that science and the humanities do, if it is be established in comparable intellectual and educational terms.’ (ibid: 223)

Examining Cross’s idea of designerly ways of knowing, it was possible to identify that the author was trying to present the idea as a framework that allowed the different areas of design knowledge to be mapped and explained how they are used by the non-design sectors:

‘Designerly ways of knowing are embodied in these ‘codes’. The details of the codes will vary from one design profession to another, but perhaps there is a ‘deep structure’ to design codes.’ (Cross, 1982: 224)

When Cross presented the idea back in the 1980s, he provided information on the steps that a designer employs when solving a design problem. Figure 3 was produced from the knowledge provided in Cross’s literature (1982 and 2006):

![Designerly ways of knowing framework](image-url)
Cross (1982: 226) identified five aspects of designerly ways of knowing, they were:

1. Designers tackle 'ill-defined' problems.
2. Their mode of problem-solving is 'solution-focused'.
3. Their mode of thinking is 'constructive'.
4. They used ‘codes’ that translate abstract requirements into concrete objects.
5. They used these ‘codes’ to ‘read’ and ‘write’ in ‘object languages’.

The framework presented in Figure 3 was created based upon the five aspects with additional information from Figure 4: ‘the derived expertise model of product design’ (Cross, 2006: 532). The first aspect of the framework: ‘an ill-defined problem/ a design problem’, was a direct reflection upon the first aspect of designerly ways of knowing. The second aspect: ‘redefine the problem different design disciplines’ knowledge’, was created as a reflection of ‘identify’ and ‘define’ elements from ‘the derived expertise model of product design’. From that model, the stages between ‘identify’ and ‘define’ suggested that a designer would redefine the given problem to a design context by identifying the constraints and requirements. With the problem redefined, the framework then moved onto ‘reframing the problem using design knowledge’. This aspect of the framework was a reflection upon the second aspect of designerly ways of knowing: ‘solution focused mode of problem solving’. To solve the problem with a solution focused approach, the designer would need to reframe the problem given to generate suitable solutions within the constraints and requirements. The next aspect of the framework: ‘synthesis, designing the solution’, was a reflection upon the third, fourth and fifth aspects of designerly ways of knowing and the ‘generate’ aspect from the model. These aspects described the solution generation phase of the design process. The final aspect of the framework: ‘solution’ was a direct reflection of ‘solution’ aspect of the model.
Figure 4 The derived expertise model of product design (Cross, 2006: 532).
Similarities can be identified in ‘the derived expertise model of product design’ and the idea behind designerly ways of knowing. They were ill-defined problems or a design problem, redefined the problem given, reframing the problem for a suitable problem solving strategy and creating solutions. Both identified the strategies that designers employed when solving design problems that have the characteristic of being ‘wicked’ (Rittel and Webber, 1973). Design problems cannot be solved by using reduction, transformation or optimisation of the data in the requirement specification as it would be impossible to provide a desired solution. In addition, it is almost impossible to have only one solution that could fit the requirements of a design brief, therefore making design problems different to scientific problems as those can be resolved by using reduction (Toulmin, 1953: 153). From a study, Cross and Kruger (2006: 527-548) was able to gather empirical evidence suggesting designers used various cognitive strategies to generate a number of solutions for the same problem presented.

Looking back to Peirce’s methodology of science, it is reasonable to view all different areas of design as having the same starting point and, therefore, the framework of designerly ways of knowing would help the different areas of design to apply the suitable methods in tackling different design problems. With the framework established, mapping, explaining and documenting the different processes that designers from different areas employed became much more practical. Designerly ways of knowing allows a designer to identify if the problem has the characteristics of a design problem. Design thinking is the cognitive process that a designer employs to solve these problems.

Cross (2011: 37–39) provided a case study that demonstrates how designerly ways of knowing led to using design thinking to create an innovation. According to Cross, the hydro-pneumatic suspension designed by Gordon Murray for the Brabham Formula One cars in the 80s was a good example because of the impact it had on car performance and competitiveness. As a result of the performance gained the team won the driver’s title. In the early 80s Formula One’s governing body (FISA) banned
the ‘ground effect’ racing cars, as they were becoming a safety concern (Cross, 2011: 37). ‘Ground effect’ race cars generated massive amounts of down force therefore providing much higher cornering speeds during a race. However, with the ban enforced, all cars were required to have a minimum ground clearance of 60mm, therefore, losing the aerodynamic grip that was generated by the ‘ground effect’ designs. To counter the loss of grip Murray came up with the idea of hydro-pneumatic suspension to recreate down force by dropping the ride height back down to 10mm during the race. The system was so successful that other teams believed it was illegal, however, FISA ruled it legal before changing the regulations again.

Figure 5 breaks down how Murray achieved a sustainable advantage using designerly ways of knowing and design thinking according to the information presented by Cross (2011: 37-39):
Designerly ways of knowing and design thinking both originated from the same time period (late 70s and 80s). To further the understanding of the relationship between them; the identification of the difference between them is required. Doing so would also determine if designerly ways of knowing is the necessary foundation that is needed before design thinking can be applied. Furthermore, understanding the origins of designerly ways of knowing can help others outside the design field to understand design thinking. The use of the term seems to be reserved to the design academia and the ownership of the term also belongs to them.
2.2.5. Designerly thinking

Looking at the history of designerly thinking, the origins of it can be traced back to the emergence of designerly ways of knowing in the late 70s (Archer, 1979a and 1979b and Lawson, 1979). The term was mostly seen in academic journal papers in the late 1970s and early 1980s (Archer, 1981 and Cross 1982) when design academics attempted to define design as a discipline.

The findings from the previous sections of this Chapter (2.2.1, 2.2.2 and 2.2.4) suggested that design thinking could be the cognitive process that designers employed to select the suitable methods, processes and designing solutions to tackle design problems and designerly ways of knowing being the design knowledge base that designers used, then designerly thinking could be identified as the style of thinking that designer used.

Archer (1981: 35) stated the following regarding the nature of design research:

‘Design, like Science, is a way of looking at the world and imposing structure upon it. Design, then, can extend to any phenomenon to which we wish to pay designerly attention, just as Science can extend to any phenomenon to which we wish to pay scientific attention.’

A closer look at Archer’s phrase ‘paying designerly attention’ lead to the belief that when a phenomenon is being given designerly attention this would require the problem solver to have a designerly thinking mind set. Looking at the history of design thinking, it could be argued that in the early days of design academics defining design as a discipline, before the term design thinking was used to describe the cognitive processes used by designers; designerly thinking was the best way to describe the mind-set that a designer had when working on design problems. As Archer wrote:
‘Design, in a certain sense, is research done backwards.’ (1991: 24)

With design solving problems in a manner which is completely the opposite to the strategies employed in science, it would require people to have a certain mind set such as designerly thinking to employ design to its maximum potential.

Designerly thinking could be seen as the early academic form for design thinking; with published literature showing evidence of the two sharing the same roots and their meanings overlapping each other at the early stages of design scholars defining design as a discipline. The design thinking processes were defined by further empirical data, application by designers in other fields and literature. The definitions of the two terms are now different. The application of design thinking professionally in the non-design fields has helped to differentiate the two terms.

Tracing its roots in published literature, the term is mainly used by academic authors for example: Anning and Hill (1998), Archer (1981 and 1991); Baynes (2009 and 2013); Cross (1999, 2011); Roberts (2005); Stables (1992); Trebell (2008) and Outterside (1993).

As a point of reference to identify if designerly thinking is the early academic form for design thinking, a search of selected library catalogue and online databases were conducted.

Searching specifically for the use of designerly thinking in the title the results from the Loughborough University Library online catalogue yielded only five results, with 80% of the literature work authored by Baynes (2009). However, searching designerly thinking in the Design and Technology Education Research (DATER, www.dater.org.uk) resource hub yielded more results. All the results provided by DATER were conference papers related to design education; the results from DATER suggest the term is still being used by some design academics. Using the database Science Direct, searching under the same guidelines no results were given and no usage was found when searching on the Design and Applied Arts Index (DAAI).
Furthermore, looking at all the literature collected to date, a number of authors were using the term design thinking rather than designerly thinking; below are a few examples from academia (Lloyd, 2013 and Dorst, 2011), design practice (Brown, 2009) and design commentary (Berger, 2009):

‘Recent approaches to design thinking can be classified in two ways. The first approach shows how methods of design can be used generically to add value to a business (Brown 2008, 2009; Lockwood 2009; Martin 2009). The second more pedagogical approach advocates designing as a way of empowering ‘non-designing’ people in resolving complex problems that go beyond business (Ambrose and Harris 2009)’. (Lloyd, 2013: 750)

‘Nowadays, “Design Thinking” is identified as an exciting new paradigm for dealing with problems in many professions, most notably Information Technology (IT) (e.g. Brooks, 2010) and Business (e.g. Martin, 2009). The eagerness to adopt and apply these design practices in other fields has created a sudden demand for clear and definite knowledge about design thinking (including a definition and a toolbox).’ (Dorst, 2011: 521)

‘Design thinking begins with skills designers have learned over many decades in their quest to match human needs with available technical resources within the practical constraints of business.’ (Brown, 2009: 4)

‘Design thinking: a process that endeavours to solve problems and create new possibilities, generally by relying on empathic research (…) combined with creative experimentation and extensive prototyping and refinement – all aimed at the goal of producing better, more useful objects, experiences, services and systems.’ (Berger, 2009: 302)

Above were some examples of the term design thinking being used instead of designerly thinking. Examining the current academic definition
of design thinking, this appears to have included the meaning of designerly thinking into it:

‘design thinking as comprising abilities of resolving ill-defined problems, adopting solution-focused cognitive strategies, employing abductive or appositional thinking and using non-verbal modelling media.’ (Cross, 1990)

The part that is related to designerly thinking would be ‘abductive or appositional thinking’ as abductive reasoning is the key to design thinking. It can be identified that designerly thinking and design thinking had the same origins but design thinking evolved differently due to its application.

As the design academia and practice evolved the term design thinking became the common term to use whereas designerly thinking became less common but the term is still being used in academia by some.

2.3. Mapping the different viewpoints of design thinking in literature

The aim of the section is to discuss and map the different viewpoints from the design and non-design sector on design thinking. Mapping out these different viewpoints presented in literature would provide a better picture of the current understanding of design thinking from the design and non-design sectors.

2.3.1. Has the meaning of design thinking changed since the 1960s due to the different usage between the design and non-design sectors?

Archer (1967: 47-51) expressed the following views on the future of design management:

The growing complexity of design problems has caused designers to investigate the methodology of design only a little more recently than managers began to investigate the methodology of management. The time is rapidly approaching when design decision making and management decision making techniques will
have so much in common that the one will become no more than
the extension of the other. (1967: 51)

Looking back at Archer’s opinion and comparing it to the interest in
integrating design thinking into businesses and other sectors, the
predictions from the opinion back then were close to today’s situation.
With the interest in design thinking application and integration to other
sectors (evidence in the form of published literature: Brown, 2009; Berger,
2009; Lockwood, 2010; Martin, 2009 and Verganti, 2009) it would be
useful to look at other factors that caused the interest from non-design
sectors.

According to Brown (2009: 165), the economic recession in 2008 was a
‘Black Swan moment’ (Taleb, 2007). ‘Black Swan’ (ibid) was a concept
that means uncontrollable external factors or ‘game changers’ events that
could affect an industry or the world. Brown (2009: 164-165) argued that
in order to minimise the effects of ‘Black Swan’ events, companies should
invest in innovation and use design thinking as a way of managing their
innovation portfolios. Brown’s argument gave the impression that the
application and integration of design thinking could counter the effects of
‘Black Swan’ events; perhaps the possibility of countering such events
triggered the non-design sectors interests in design thinking.

Brown’s argument perhaps was similar to what the Council of Industrial
Design (CoID, now the Design Council) did after World War II when the
country needed rebuilding with the economy trying to recover. ‘Britain Can
Make It’ was an exhibition created to showcase design and manufacturing
(Ford and Davis, 2008). Another important contributor alongside the
Design Council to the 1946 ‘Britain Can Make It’ festival was the Design
Research Unit (DRU). The DRU was found in 1943 by Sir Misha Black and
Milner Grey (Sir Misha Black Awards, 2012). This was one of the first
international and multidisciplinary consultancies to be seen in the UK. It
was the main driving force behind the 1951 Festival of Britain. Other
iconic projects that the DRU was involved in included the Westminster’s
street signs and British Rail train designs in the 60s and 70s (The Sir
Misha Black Awards, 2012). An example of businesses interested in
employing design after the economic crisis of 2008 was given by Mau (founder of Bruce Mau Design, Canada) during an interview with Berger (2009: 23). Mau stated (ibid) that an increased number of businesses were interested in employing his firm to solve their problems. In addition to the economic factor, Dorst (2011: 521-522) argued that the evolution of design industry was also a factor that triggered the non-design sector’s interest in design thinking. With many consultancies switching to a more strategic approach using design thinking as a tool, designers now participate from the start to the end of creative processes, turning design into a strategic tool for many from the non-design sectors (Berger, 2009: 6-7).

An example to support the evolution of the design industry would be the transformation of the design consultancy IDEO. Brown (2009: 103) commented that external factors caused IDEO to change its approach in business. According to Brown the major factors behind the evolution of IDEO was the end of the ‘dot-com supernova’ at the end of 2000 and ex-CEO David Kelly leaving to focus on his academic duties at Stanford University. In order to survive the company had to evolve into what Brown called ‘IDEO 2.0’. The brief was to reposition the company to suit the constant changing environments which the firm found itself in. During the transition period three ideas were brought forward and they would be the foundation of ‘IDEO 2.0’:

1. “Design with a small d” – using design as a tool to improve the quality of life at every level.

2. “One IDEO” – the notion that our future depended on our acting not as independent studios but as a single interconnected network.


‘IDEO 2.0’ fitted well into Archer’s work in the late 1970s when he was defining design as a discipline. The papers and journal articles that were written in that period mentioned design’s potential to shape the future and being applied to a much wider context. Looking at this example of a
design consultancy reinventing itself, the evidence suggested the change was caused by external factors. Perhaps the design industry needed external game changing factors, such as the end of the ‘dot-com supernova’ (Brown, 2009: 102) and changes in people’s and businesses’ behaviour (Esslinger, 2009: 9-10) to force itself to reorganise, rethink and move on to the next level.

In order to map the possible changes in design thinking, the contexts that design thinking has been applied in must be examined. Exploring design thinking’s application contexts could help understand where the difference viewpoints originate from.

As previously discussed (Chapter 2.2.1), the literature evidence suggested that design thinking is the solution-focused process, which designers employ to tackle design problems that are ill-defined. Therefore, it is an ability that all designers have as it is a vital component for the design industry to function. However, in the last decade with some design consultancies repositioning themselves in a more strategic light, design thinking became a tool that the design industry uses to create the separation between those operating at a ‘higher’ level with a strategic approach from those that operate further downstream in the creative process.

Those who operate at ‘a higher level’ could argue that the hierarchy was a natural part of the evolution of the design industry as it expands its influence and methods into other sectors. If this is the case then design thinking could be a useful indicator for those from the non-design sectors who are interested in hiring designers to tackle non-design problems.

However, it would be inappropriate to claim using design thinking will guarantee innovation and success as Martin (2009: 57–78) commented that thinking like a designer and applying abductive reasoning to problems of business would create a sustainable advantage. Martin appeared to be sure about design thinking giving a ‘competitive advantage’ and so a closer look at the Research In Motion (RIM) case study (ibid: 51–78) from the book was required.
RIM is the technology company that designed and created the Blackberry smartphones. According to Martin, thinking abductively within the company was one of the competitive advantages for innovation RIM had over its competitors. By employing design thinking, RIM was able to identify an opportunity in the mobile communication market with laptop users demanding smaller devices that required a standard QWERTY keyboard. The BlackBerry launched in early 1999 was a product that slotted into the market gap. The device had a QWERTY keyboard, which would become the signature feature of the BlackBerry brand and email capability. With the BlackBerry entering the market RIM grew sharply from 50 million USD in revenue in 1999 to 11 billion USD in revenue by 2009 (Martin, 2009: 57-61 and 69).

For a decade, applying design thinking gave RIM a competitive advantage over its competitors. When the book was published back in 2009, the RIM case study was a convincing pitch regarding the potential of design thinking (ibid: 57-78). Looking at the RIM in 2012 the company’s fortunes have turned dramatically since 2009. The BlackBerry devices are no longer the dominant force that they once were in the smart phone market. The BlackBerry 10 operating system was not launched until late 2012 and Lazaridis the founder of RIM resigned from the company (BBC News, 2012). The events occurred within RIM since 2009 suggested that design thinking can open up new opportunities on the market but it is not a guarantee in sustaining success.

However, Martin (2009: 79–103) did list a successful case study of applying design thinking in changing a company. The transition of Procter & Gamble (P&G) was the case study he chose to show how powerful design thinking is. P&G was in a transformation period at the beginning of the 21st century. During the restructuring process a merger with Warner-Lambert and Wyeth failed and the share price dropped 30% in a single day. As a result, the board members fired the CEO. The company then appointed Lafley as CEO and tasked him to turn the company around to be more innovative and win back its customers. With this goal the company started the process of transforming itself into a design thinking
organisation. In order to achieve his goal Lafley appointed Claudia Kotchka as the vice president of design strategy and innovation. Kotchka’s task was to build P&G’s design capability and act as the corporation’s champion of design thinking. With the aim of turning the company around in five years, Kotchka sourced external expertise from IDEO, the external design board and a trio of academic design school deans (Martin, Kelly and Whitney) for help. As the transition process moved on, a prototype design thinking training course emerged for P&G business leaders and according to the program these are the three essential parts to design thinking in a business context:

- Deep and holistic user understanding
- Visualisation of new possibilities, prototyping, and refining
- The creation of a new activity system to bring the nascent idea to reality and profitable operation (Martin, 2009: 88)

The training course was designed specifically for business teams to get hands on experience in applying design thinking into their daily tasks. As soon as the course was refined and P&G learnt how to run it designers seemed to be phased out. The course has successfully delivered a design thinking tool kit for the managers at P&G. The company then went on to adopt the design thinking approach into other parts of the company such as Research and Development and Global Business Services. Overall the transformation of P&G was successful as it became one of the top ten most valuable companies in the world.

The P&G example was a compelling case study of design thinking transforming a global company. Despite P&G’s successful application and integration of design thinking, Burdick’s (2011) viewpoint of design thinking being used as a branded phrase for innovation can be identified. Examining the later part of the case study, the training course is a good example of suggesting design thinking can guarantee innovation. The description of the training course appeared to give the impression that upon the completion of the course; the participants would be granted the ability of employing design thinking to generate innovations. In addition,
looking at the timeline of the case study from 2000 to 2009, it suggested that designers were only involved at the beginning to share the knowledge. There was no indication of designers participating in other activities during the reform process. The lack of evidence seemed to suggest designers were only involved at the beginning rather than throughout. The outcome of the case study gave the impression that businesses were embracing design thinking as an innovation tool.

Martin’s views on design thinking did not reference the academic origins of design thinking. Martin’s viewpoint of design thinking appeared to focus on the application and linking it to creating innovation. Overall there was enough evidence to suggest design thinking had turned into a phrase relating to innovation for non-design sectors.

Other than Martin, some believed in applying design thinking would yield innovation (Berger, 2009; Brown, 2009; Lockwood, 2010; Verganti, 2009). A number of academics and practitioners jumped on to the trend of believing design thinking was too important to be left with designers as they were keen to take advantage of the growing interest in design thinking’s application. The P&G case study showed there are no guarantees that employing design thinking would change any business’ fortunes overnight.

Perhaps because of design thinking being linked to guarantee innovation, it led some to call design thinking a myth or as Nussbaum (2011) called it: a failed experiment and stated it was time to move away from design thinking. Nussbaum was one of the advocates of design thinking from the business sector. He was once quoted asking the question ‘Is design too important to be left only to designers? (Nussbaum, 2009).’ Back then Nussbaum believed design was only at the beginning of turning into a more powerful medium as the discipline absorbs more new knowledge.

Moving forward to 2011, Nussbaum was publicly criticising design thinking and questioning the abilities of design consultancies saying the success rate of design thinking is very low.
Nussbaum claimed the success rate of creating innovation by using design thinking was too low (no evidence was provided in any of his publications); therefore, it was time to move on to the concept of creative intelligence (CQ). CQ (Nussbaum, 2013) was a concept created by Nussbaum and he claimed it is next evolution of design thinking. From Nussbaum’s perspective design thinking was no longer useful; therefore it was time to move onto CQ. However, the CQ concept was based on design thinking therefore it seemed to be contradictory to base the new concept on ‘a failed experiment’ as suggested by Nussbaum. The CQ concept can be seen as an example of practitioners from non-design sectors of portraying design thinking in a different light.

Looking from the design practitioners’ point of view the most notable advocate for design thinking would be Brown (2009), the CEO of IDEO. From his viewpoint design thinking is a powerful approach for innovation that is effective and accessible to any industries or sectors that wish to employ it. According to him, businesses around the world need to integrate this approach as innovation is the key to long term survival. The integration of design thinking will ensure that. Brown presented a convincing case on how powerful design thinking is. However, as Roozenburg (2010) pointed out Brown failed to show the following:

‘In summary, we can state that Brown’s (2009) ‘new’ design thinking approach presents a prescriptive or even idealistic view, which is ultimately formulated at a rather low resolution level. The instructions are not empirically nor theoretically supported; they are a generalization of his own experience packed in a kind of popularized management problem solving approach.’

Brown could be seen as an example of a design practitioner portraying design thinking in an innovation-biased vision. As a result of this, design thinking was presented as a process that almost guaranteed innovation. Despite portraying design thinking in such a manner, it could argued that Brown has brought some welcome attention from the non-design sectors to the design industry by showcasing the potential of design thinking, regardless of the lack of theory from his approach.
2.4. Development of the research’s starting position

With a number of 2009 publications claiming design thinking as a ‘new approach to innovation’ (Berger, 2009; Brown, 2009; Martin, 2009; Lockwood, 2010 and Verganti, 2009) it was necessary to address whether the process of design thinking has changed at all. In order to do so, a set of design projects from the 60s to present were selected from literature already reviewed and examined under the following three categories:

1. External factors: what were the external factors that sparked the project?
2. Who: who were the people involved?
3. Outcome/result: what were the outcomes?

These three questions were developed from the evidence that appeared from the literature review. Category 1 was developed from the ‘Black Swan’ theory by American essayist Taleb (2007) whom Brown quoted (2009: 165 and 241). Taleb explained the ‘Black Swan’ is an event of the following three attributes:

‘First it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable.’ (Taleb, 2007)

Taking a deeper, more in depth look into the case studies that are provided from literature, the evidence showed that all these cases of design thinking in application were initiated by a ‘Black Swan’ or game changer. An example of a ‘Black Swan’ would be the advance and development of the Quartz technology in the watch industry between 1970s – 1980s (Verganti, 2009: 69-73). The development of the technology changed the Swiss watch industry and led to the creation of the Swatch watch. Further examples of ‘Black Swans’ are presented in Chapter 2.4.1–2.4.6. If the initial theory was to be correct then all these ‘Black Swans’ could be proof of design thinking being used in different industries as they look for possible solutions. As Dorst
(2011) commented, the design industry is evolving therefore leading design thinking to be applied in other contexts.

As books written by practitioners like Brown (2009: 13) claiming design thinking being a process that involves multi-disciplinary teams that would lead to innovation and Martin (2009: 151–177) also claiming anyone could use design thinking, then it was necessary to look at who were involved in these design thinking case studies. If the initial theory was correct, the experts from different fields and users participating in these case studies would be identified from the data.

Martin wrote:

‘Thinking like a designer can create sustainable advantage.’ (2009: 57)

Martin along with others such as Brown (2009), Cross (2011), Esslinger (2009) and Verganti (2009) believed that applying design thinking would create a sustainable market advantage or generate innovation. Esslinger wrote:

‘The goal of any business strategy is to achieve measurable success.’ (2009: 35)

In 2011, Cross wrote:

‘Everyone can – and does- design. We all design when we plan for something new to happen,’ (2011: 3)

The quotes summed up the literature evidence from Chapter 2.2 and 2.3 that suggested design activity can be conducted by any human and are possible due to humans occupying a specific cognitive niche. Category 2 was developed based on this evidence.

From the literature evidence, it would be reasonable to believe those who employed design thinking expected to see a positive result that can be measured. Category 3 examined the outcome of the case studies and investigated the impact of how successful those organisations were after adopting the design thinking approach. This final category would be another
useful indicator to prove the initial theory being correct as it access the positive impact resulted from applying design thinking in different domains.

The aim of the analysis was to identify a set of common characteristics of design thinking application within the design projects selected.

Content analysis was selected to analyse the six design projects selected. It was a suitable method of analysis because it allowed the construction of categories, in this case the possible common characteristics of design thinking. Content analysis contained three stages of coding: open coding, axial coding and selective coding. In open coding, the data was split into discrete parts. Here, the data was split according to the three categories of external factors, who and outcome. In axial coding, the data coded under the three categories was coded into sub categories as supporting evidence for the categories. Finally in selective coding, all the data coded under the three categories was re-examined to identify the possible common characteristics of design thinking application.

The following section presents the six design projects that were analysed via content analysis to identify possible common characteristics of design thinking application and identify if the process of design thinking has changed since the 1960s.
2.4.1. Design project 1 – The Kings Fund Hospital Bed project 1963 – 1975

Project background

The first design project was examined by the three categories is The King’s Fund Hospital Bed Project. This design project was presented in Lawrence’s (2001) doctoral thesis: *Hospital beds by design: a socio-historical account of the ‘King’s Fund Bed’, 1960-1975*, Baynes’ *Design: Occasional Paper No.4* (2009) and *Change by Design* (2013).

Back in the 1960s the UK government put in motion a £500 million Hospital Plan for the NHS. Part of the plan was to help the NHS to save costs. It was identified that standardising hospital equipment could help the organisation to save money when equipping the new hospitals and as a result the movement of standardising hospital equipment was speeded up in 1965 (Lawrence, 2001: 33). The King’s Fund Hospital Bed project started in 1961 and the project was being led by Bruce Archer. However, the designing of the bed did not begin until 1963. For the project Archer employed the systematic design method, which he introduced in 1963.
through a series of journal articles. These articles would eventually be published as a book under the title of *Systematic Methods for Designers* (Archer, 1965). The design methods introduced in those articles were mainly designed for The King’s Fund Bed project; however, Archer argued that as design problems becoming more complex the same methods can be applied to other design problems (Lawrence, 2001: 66–67, 77–78). Once the method of design was chosen Archer then assembled a multidisciplinary team at the Royal College of Art to conduct the project (Baynes, 2009: 15).

The first phase of the project was to develop a specification for the bed design. In addition to standardising hospital equipment one of the aims of the project was to create a ‘gold standard’ specification of hospital bed to be used for evaluating rival designs (Baynes, 2013: 65). The questionnaire that determine the important functions on specification was drafted by information provided from potential users; in this case they were a ward sister and a nursing research officer. In addition to them London hospital teaching staff was also involved. The final specification was created from data gathered via questionnaires sent to hospitals in London in 1963 (Lawrence, 2001: 93–100). With the specifications created the RCA team moved onto designing and prototyping. During this phase of the project the team created a prototype bed according to the specification as an example for rival companies; the first prototype was created by an industrial designer, an aeronautical engineer, a medical draftsman and a sheet metal craftsman (Baynes, 2013: 70). Eventually the RCA team commissioned an order for twenty prototype beds to be built for simulation trails and performance evaluation (Lawrence, 2001: 113). After the field trials and evaluation a batch of two thousand beds went into production in 1967, the aim of the production run was to perfect the manufacturing techniques and generate a realistic cost estimate. The King’s Fund had trouble selling the bed initially as their design was double the price compare to others. But eventually after a marketing drive, the sales of the bed increased and since 1974 a rough estimation stated that 50% of new hospital bed purchases were the King’s Fund design (Lawrence, 2001: 124). According to the RCA the
King’s Fund bed design is still in use today. RCA claims 85% of existing UK hospital beds are built to the King’s Fund specification (Royal College of Art, 2012).

In addition to creating a ‘gold standard’ specification for hospital bed design, the project also shed light on the nature of design activity and how it is conducted (Baynes, 2009: 15).

**Examination and findings**

Table 2 presents the findings of this design project against the examination categories.
<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External factors:</strong> What were the external factors that sparked the project?</td>
<td>The UK government’s £500 million Hospital Plan for the NHS in 1960s and the plan to standardise hospital equipment (Lawrence, 2001: 33). Develop a standard specification of hospital bed to be used for evaluating rival designs (Baynes, 2013: 65).</td>
</tr>
<tr>
<td><strong>Who:</strong> Who were the people involved?</td>
<td>A multidisciplinary team that was assembled by Archer at the Royal College of Art (Baynes, 2009:15). The specifications of the bed were created by a ward sister and a nursing research officer (Lawrence, 2001: 93-100). The prototype bed was created by an industrial designer, an aeronautical engineer, a medical draftsman and a sheet metal craftsman (Baynes, 2013: 70).</td>
</tr>
<tr>
<td><strong>Outcome/result:</strong> What were the outcomes?</td>
<td>A rough estimation in 1974 stated 50% of new beds purchased by UK hospitals was the King’s Fund bed design (Lawrence, 2001: 124). According to the RCA, 85% of the existing UK hospital beds are built to the King’s Fund bed specification (RCA, 2012). In addition to the wide application of the bed design, the RCA (2012) claimed the project demonstrated how medical products could be designed and showcased the value of the evidence-based design process. Baynes (2009: 15) also claimed the project shed light on the nature of design activity and how design activity is conducted.</td>
</tr>
</tbody>
</table>

Table 2 Examination categories and findings from Design project 1
2.4.2. Design project 2 – Brabham F1 car suspension design, 1981

Project background

The second design project was examined was the Brabham F1 car suspension design for the 1981 season. This project (suspension design) was presented in Cross’s book *Design Thinking* (2011: 31–39). Additional information on the design project was found on the Atlas F1 team’s (now part of Autosport) website.

The background to this project has been previously discussed in Chapter 2.2.4 (page: 43-45).

Examination and findings

Table 3 presents the findings of this design project against the examination categories.
<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External factors:</strong></td>
<td>The FISA (now the FIA) changing the 1981 season regulations and banning ‘ground effect’ car designs due to safety reasons, the new rules also stated the cars must have fixed skirts and have a ground clearance of 60mm (Cross, 2011:37).</td>
</tr>
<tr>
<td><strong>What were the external factors that sparked the project?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Who:</strong></td>
<td>Gordon Murray, the Brabham F1 team’s chief designer and the team’s engineers.</td>
</tr>
<tr>
<td><strong>Who were the people involved?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Outcome/ result:</strong></td>
<td>A new suspension design that would lower the car as the speed increased and raised the car back to the required ride height when stationary (Cross, 2011: 37 -39). Nelson Piquet qualifying on pole three times and won one Grand Prix in the first six races of the 1981 season, he would eventually win the 1981 Driver’s title in the Murray designed car (Stats F1, 2012). The FISA banned the suspension design as it was considered to be too competitive (Cross, 2011: 39) Cross claimed this is a great example of employing design thinking to gain a competitive advantage in a competitive sport (Cross, 2011: 31-39)</td>
</tr>
<tr>
<td><strong>What were the outcomes?</strong></td>
<td></td>
</tr>
</tbody>
</table>
2.4.3. Design project 3 – Mothercare Via Multibuggy, 1985

![Image of Mothercare Via Multibuggy](image.png)

**Figure 8 Mothercare Via Multibuggy (Sebastian Conran Associates, 2013)**

**Project background**

The third design project examined was the Mothercare Via Multibuggy. This project was presented by Sebastian Conran at a public lecture given to Loughborough Design School in April 2013 (lecture not available via Loughborough University; however, it is available at an alternative site see reference for details). Additional information of the project can be found on the Sebastian Conran Associates’ (SCA) website.

In 1981 Sebastian Conran joined Mothercare as the lead in hard goods design. In this role he was in charge of transforming the entire Mothercare product line up. During his five years stint with Mothercare he and his team transformed the brand’s image and product identity with ‘soft touch’ visual language (SCA, 2013). One of the most noticeable products designed by his team for Mothercare during that period was the Via Multibuggy. Prior to the launch of the Via Multibuggy in 1985, the majority of the pushchairs on the market were made from metal therefore they were bulky and heavy in weight. However, the Via buggy was different to its competitors. The materials used were polymer and aluminium. The
decision to use this material combination according to Conran (2013) himself was taken after spending time researching other products. The team used a ski boot as an example of a product that is tough, lightweight and affordable. With the research of the ski boot the design team looked in detail at the design, construction and manufacturing processes used in creating the sporting goods. The team along with the manufacturer identified how the technology could be transferred to create baby buggies. As a result of identifying the potential of using polymer in baby buggy design the end product was the first ever buggy to feature structural plastic parts. The Via buggy can hold a child from birth to three years old with the maximum weight of 30 kilograms allowed and take a cart of shopping.

According to SCA, the design of the Via buggy is a ‘classic case of user-centric design’ (SCA, 2013) where the design team managed to integrated desirable user features into the design of the product (Conran, 2013). As a result of employing user-centred design the product was a huge success in the market and became the market leader within a short space of time.

**Examination and findings**

Table 4 presents the findings of this design project against the examination categories.
<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External factors:</strong> What were the external factors that</td>
<td>Mothercare’s desire to create a new brand language and overhaul its product identity with ‘soft touch’ visual language (SCA, 2013). New transferable construction and manufacturing process in polymer (Conran, 2013).</td>
</tr>
<tr>
<td>sparked the project?</td>
<td></td>
</tr>
<tr>
<td><strong>Who:</strong> Who were the people involved?</td>
<td>Sebastian Conran, Mothercare hard goods design team, Mothercare’s manufacturing contractor and existing Mothercare customers.</td>
</tr>
<tr>
<td><strong>Outcome/ result:</strong> What were the outcomes?</td>
<td>Launched in 1985, the Via Multibuggy was the first pushchair to incorporate a polymer and aluminium construction. As a result of the material it was much lighter than its competitors. Conran (2013) claimed during a lecture the Via Multibuggy outsold the previous model by 600%. The product was critically acclaimed in the press. As a result of the product’s design and success Mothercare was awarded the Horner’s Wards from the British Plastics Federation back in 1985 (SCA, 2013).</td>
</tr>
</tbody>
</table>

Table 4 Examination categories and findings from Design project 3
2.4.4. Design project 4 – Alessi Family follows Fiction range, 1991

Project background

The forth project examined was the Alessi ‘Family follows Fiction’ household product range launched in 1991. This project was presented in Verganti’s book (2009: 40–44, 46–47) and Loh, Lee and She-reen’s book Alessi (2009: 111–117).

Back in the early 90s Alessi launched a research initiative named Centro Studio Alessi (CSA). The aims of the initiative were the following: to investigate new methodologies in design with young designers; explore other disciplines such as communications, marketing and anthropology to generate insights for the company. Through the research initiative, an evidence based three stage design process was born. The first stage is research, the aim of this stage is to identify insights, criteria, directions and the designers involved. Once research has been conducted the design teams will then provide concepts and select which projects will be moved into further development. The final stage of the process is development and manufacturing. The ‘Family follows Fiction’ household product range was a direct result of employing such design processes (Loh et al, 2009: 111).

According to Verganti (2009: 40–42) the research carried out by Winnicott, a paediatrician and psychoanalyst on transitional objects (for
example teddy bears and toys etc.) and how children associate their feelings with them was one of the major insights that pushed the Family follows Fiction project forward. In addition the affective code theory developed by Fornari, an Italian neuro-psychiatrist and psychoanalyst was also another major insight for the project. The theory implies all objects communicate a message to people out of the following five codes: paternal, maternal, childish, erotic and life or death. Once these insights were identified a research team was assembled by Alberto Alessi himself to explore how to use these insights. The research team consisted of in-house designers and additional external advisors including a consumer food culture expert and an architect. The research team suggested that the best way to move forward was for Alessi to produce a family of products concentrating on the concept of toys from the transitional objects research. Once the direction was identified the design team produced a family of colourful playful products made from plastic driven by the concept of transitional objects.

In addition to the psychology research of the time a technological factor that led to the birth of the ‘Family follows Fiction’ range was Alessi’s decision to investigate the possibility of using plastic as the main material of its products. Prior to the launch of ‘Family follows Fiction’ the majority of Alessi’s products were made from steel and several different types of metals (Loh et al, 2009: 111).

The Family follows Fiction product range was the first Alessi product range to be made out of plastic. It helped the company to open a new market sector in terms of everyday consumer products around the world and many of the products became the company’s best sellers (Verganti, 2009: 42–43).

**Examination and findings**

Table 5 presents the findings of this design project against the examination categories.
<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External factors:</strong> What were the external factors that sparked the project?</td>
<td>New research findings on the relationship between children and transitional objects such as teddy bears (Verganti, 2009: 40-42). Developments in injection moulding and the use of plastics (Loh et al, 2009: 111).</td>
</tr>
<tr>
<td><strong>Who:</strong> Who were the people involved?</td>
<td>A research team consisted of in-house designers from Alessi; external advisors of the following: consumer food culture expert and an architect (Verganti, 2009: 40-42)</td>
</tr>
<tr>
<td><strong>Outcome/ result:</strong> What were the outcomes?</td>
<td>According to Verganti (2009: 42-43), the product range was responsible for doubling Alessi’s revenue in the early 90s. Furthermore it also helped to attract new customers to the company.</td>
</tr>
</tbody>
</table>

Table 5 Examination categories and findings from Design project 4
2.4.5. Design project 5 – Nintendo Wii console, 2005

![Image of Nintendo Wii console](image-url)

**Figure 10 Nintendo Wii (Amos, 2010)**

**Project background**

The fifth design project examined was the Nintendo Wii console launched in 2005. The project was presented in Verganti’s book (2009: 60–67) and additional details of the projects were found in *The Guardian* newspaper (2003, 2005) and MIT’s *Sloan Management Review* (2011 and 2012).

The Nintendo Wii console was revealed at the 2005 E3 (The Electronic Entertainment Expo) Exhibition. The console was the end result of Nintendo’s project ‘Revolution’, the company’s next generation console project started back in the early 2000s. The aim of the project was to create a product that would bring Nintendo back on terms with its rivals. Before the Wii console entered the market in 2006, Nintendo was in trouble. Its rivals Microsoft and Sony’s product were outselling Nintendo’s offering. Nintendo was losing out to Microsoft and Sony’s products which offered more complex games and superior graphics (Kim, Lamont, Ogasawara, Park and Takaoka, 2011). The Nintendo Game Cube, launched in 2001 was selling 44% short of the company ‘s2002
estimation of 10 million units (Teather, 2003). As a result of the poor sales, game developers started leaving the Game Cube as the low volume of consoles in the market meant that it made little commercial sense for them to develop games for it (Verganti, 2009: 60–67).

According to Kim et al (2011) and Verganti (2009: 60–67) the ‘Revolution’ project team, led by five Nintendo veterans with 20 plus years’ experience in the industry came to the consensus that the power of a console is not everything as they believed too many powerful consoles cannot coexist in the market. Therefore the team decided to look for alternative technologies that would feature in the console rather than building another high performance console. By 2003 at the halfway point of the project the team proposed that the ‘Revolution’ console should be designed according to the following points: relatively inexpensive compared to rival products, family friendly and appealing to mothers who have control over the living room. Under those guidelines the design team starting thinking about a more user friendly inclusive gameplay experience. As a result of that a specialised controller design team was formed. Within the controller design team their task was to bring the concept of the ‘controller as an extension of the human body’ to life. The technology that was chosen to bring this concept into products was the MEMS accelerometers. These sensors were used in the automotive industry, mainly in airbags as their function is to sense movement in three physical dimensions (x, y and z). These sensors were the key components that transformed the Wii gaming experience from the traditional button based approach to a physically active one. The interaction of user and console was vital to the console’s success. As a result of breaking the traditional image of gaming and how users interact with consoles, Nintendo managed to tap into a whole new market segment and changed the perceptions of gaming. The console has been extremely successful since its launch. It helped Nintendo’s share price to increase dramatically, forced Microsoft and Sony to lower their consoles’ retail prices and opened a whole new market for the gaming industry.
Examination and findings

Table 6 presents the findings of this design project against the examination categories.

<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External factors:</strong></td>
<td>The Game Cube fell short of Nintendo’s 2002 sale estimation by 44%, as a result causing game developers to concentrate their resources to other platforms (Teather, 2003). Nintendo only managed to sell 21.8 million Game Cubes compare to Microsoft selling 24 million Xboxes and Sony selling 120 million Play Stations (Verganti, 2009: 62). The availability and adaptation of MEMS accelerometers technology (Verganti, 2009: 60-67)</td>
</tr>
<tr>
<td><strong>Who:</strong></td>
<td>The console was developed by Miyamoto senior marketing director at Nintendo and the team from Nintendo’s Entertainment Analysis and Development. User testing was conducted by Nintendo’s staff families (Verganti, 2009: 63 and Kim et al, 2011)</td>
</tr>
<tr>
<td><strong>Outcome/ result:</strong></td>
<td>According to Verganti (2009:66) Nintendo stock prices rose by 165% in 2006. As a result of the Wii’s sale numbers in 2007 (10.57 million units) Microsoft and Sony lowered the prices of their products and led to the development of motion based controllers from Microsoft and Sony. The Wii managed to introduce a new market segment for the industry.</td>
</tr>
</tbody>
</table>

Table 6 Examination categories and findings from Design project 5
2.4.6. Design project 6 – TSA Security Checkpoint evolution by IDEO, 2009

Figure 11 The TSA Security Checkpoint Evolution by IDEO (IDEO, 2009)

Project background

The final design project examined was the TSA (Transportation Security Administration) Security Checkpoint Evolution by IDEO. The project featured in Brown, CEO of IDEO’s book (2009: 185–188) and IDEO’s website (2013). IDEO is one of the world’s leading design consultancies focused on creating innovations in the public and private sectors (IDEO, 2013).

According to Brown (2009: 185–188) TSA contacted IDEO to commission the firm to redesign their security checkpoint. This project demonstrated design thinking’s ability to involve users therefore leading to the improvement of performance in large scale systems. The TSA wanted to improve the security checkpoint environment to reduce the side effects of passengers going through their security checks. Security checks at airports became a stressful process due to new ways of hiding explosives from existing screening technologies. The stress of security checks caused the passengers to be less cooperative hence making the checks less efficient (IDEO, 2013).

Before the design of the new security layout began, the design team at IDEO conducted a lengthy period of user research. During the research
phase designers from IDEO observed the security check procedures at several airports in the USA. From the observations they identified that passengers became aggressive and uncooperative when additional checks were required. As a result of the passengers’ reactions the security officers reacted in an intimidating manner therefore creating an unpleasant experience for both parties. In addition to observations, according to IDEO, 300 plus in depth interviews were conducted with passengers, airline staff and TSA staff members. From the observations and interviews it was identified that reducing the level of stress can help speed up the security checks therefore making the experience more pleasant. Doing so would also help the TSA staff and passengers relax, making it easier for the staff to identify those with ‘hostile intent’ (IDEO, 2013).

Once this insight was identified the TSA realised redesigning a physical space is not enough, in order to improve the passengers’ and staff’s experience a new service approach was required. With this in mind the design team at IDEO worked with the TSA to create a new service blueprint for the new security checkpoint. The service blueprint contained the new layout design and strategy of the new checkpoint experience. The new design was piloted in a few locations to identify possible areas of improvement. Once the design was finalised TSA and IDEO co-created a new training program for existing and new TSA staff. The training program was vital as it help the TSA staff to embrace a new working mentality that was key to the new checkpoint design performs as intended. The checkpoint design by IDEO was rolled out across the USA since 2009. As a result of the project all TSA staff is now trained according to the IDEO designed program.

Examination and findings

Table 7 presents the findings of this design project against the examination categories.
<table>
<thead>
<tr>
<th>Examination categories</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>External factors:</td>
<td>New methods of hiding explosives against existing screening technology used at airport security checks. The TSA wanted to redesign their security checkpoints to reduce stress for staff and passengers as well as increasing the chances of detecting security threats (Brown, 2009: 185-188)</td>
</tr>
<tr>
<td>Who:</td>
<td>IDEO design team, TSA staff, airport and airline staff as well as passengers.</td>
</tr>
<tr>
<td>Outcome/ result:</td>
<td>According to Brown (2009: 185-188) and IDEO (2013), the new design and training adapted by the TSA reduced the stress and user experience of TSA staff and passengers as a result, the chances of detecting security threats also increased. Furthermore since 2009, the checkpoint layout has been widely adapted by airport worldwide.</td>
</tr>
</tbody>
</table>

Table 7 Examination categories and findings from Design project 6
2.4.7. Findings from design projects in literature

Figure 12 provides an overview of the content analysis conducted on the six design projects. From the examination, it appeared that the six projects shared four common characteristics. They are:

- Drivers:

Drivers were the factors (external or internal) that kick started any project. Drivers kick started a project by either stimulating the identification of a problem or an opportunity. In the context researched, an example of a technology related external factor would
be choosing to use polymer as the main material of the Mothercare Via Multibuggy, when the product was launched it was the first buggy in the market to use polymers as its main material (see Chapter 2.4.3). An example of a marketing related external factor would be the poor sales of the Nintendo Game Cube against Microsoft and Sony’s products. As a result of that the Nintendo design team took the decision to look at alternative technologies for their new console (see Chapter 2.4.5).

- Experts

Experts were the people from different disciplines who were involved with the project because their expertise was required to help generate suitable solutions to the problem. In the context researched, the following examples were identified as experts from a design project presented in the literature review (Brown, 2009: 185 – 188 & IDEO, 2013): product and service designers, Transportation Security Administration (TSA) security agents, airlines staff at terminals and passengers. In addition to being examples of experts, this is also an example of possible constituents for a multidisciplinary team (see Chapter 2.4.6).

- Impact

Impact was the result of using design thinking to solve the problem identified. In the context researched, impact could be a new product created by using design thinking. An example of that could be the outcome of the King’s Fund Hospital Bed project. The bed design became the standard of hospital beds and it is still being used today (see Chapter 2.4.1).

- Processes (CC)

Processes (CC) were the strategies, steps or processes developed or used to solve the problems given. In the context researched, examples of process would be the ‘user centred design processes’. Examples of those processes being employed could be seen in the
Mothercare Via Multibuggy project (see chapter 2.4.3) and TSA Security Checkpoint Evolution project by IDEO (see Chapter 2.4.6).

2.4.8. Starting position developed from literature findings

From the literature review, it was identified that the articulation of design thinking changed subtly since the 1960s. Comparing the different viewpoints of design thinking, the evidence suggested that design thinking is a process that designers employed to solve ill-defined problems. However, the subtle differences between the articulations are the emphasis on the cognitive processes behind design thinking and the specific areas or elements of application. For example, the following elements of design thinking were common among a number of academic viewpoints:

- Abductive reasoning is a vital part of design thinking (Lawson, 1979; Roozenburg, 1993).
- Design thinking is a way resolve ill-defined problems (Cross, 1982 & 1990; Rittel & Webber, 1973)
- Design has its own unique way of problem solving different to humanities and science (Archer, 1979b; Lawson 1979, Cross 1982 & 1990)

However, the practice viewpoints are different despite sharing an aspect with the academic viewpoints. Both sets of viewpoints shared the aspects of solving ill-defined problems but the following elements reoccurred regularly in a number of practitioner viewpoints:

- Design thinking is an approach to problem solving that can create a competitive advantage (Berger, 2009; Clark and Smith, 2010 and Martin, 2009)
- Design thinking is an approach that allows organisations to engage with users via empathic research (Ambrose and Harris, 2009; Berger, 2009 and Brown, 2009)
Design thinking can solve problems in any given contexts, (Berger, 2009; Brown, 2009; Clark and Smith, 2010 and Martin, 2009)

From the evidence above, the difference in articulation appeared to be in the emphasis of certain methods of design thinking application and the contexts in which design thinking is being applied. The design projects analysed to develop the starting position further highlighted the different contexts of which design thinking is being applied in; those contexts were: medical equipment, motorsport, household product, gaming and technology, airport security and counter terrorism.

From the findings the following starting position was developed:

The articulation of the meaning of design thinking has subtly changed since the 1960s but the context of where it is being applied has transformed dramatically.

2.5. Conclusions from the literature review

To conclude the articulation of design thinking has subtly changed since the 1960s. Those changes can be seen in the differences how academics and practitioners portray design thinking. The academic articulations emphasise on the cognitive aspects of design thinking (see Chapter 2.5). The practitioner articulations; however, focused on the different contexts in which design thinking can be applied, certain methods within design thinking application and the possible advantage design thinking application can bring (see Chapter 2.5). Despite their differences both sets of perspectives shared the element of design thinking being a process that solves ill-defined problems. The biggest change is the contexts in which design thinking being applied have widened and dramatically changed. This appeared partly due to the design industry evolving and expanding its influences into other industries. In addition, external factors such as the 2008 economic meltdown and the interest from non-design sectors, especially from the business world have given the opportunity for design thinking to be applied differently.

Due to the great interest from those outside design there is an apparent increased demand for a design thinking toolkit for those who wished to learn
how to employ the process into their daily tasks. As the interest increases some practitioners claimed design thinking to be an innovation tool that could help many to survive the challenges that are coming ahead. However, those claiming that design thinking can guarantee innovation and competitive advantages give the impression that there is no need to acknowledge the origins of the process and phase out the design element in it.

With the hype of using design thinking outside design, it has caused many to question the true value of design thinking. Because of the lack of theories, models or a tool box for those outside design to see the process working, many are calling design thinking a myth or a marketing spin used by major design consultancies around the world to ensure to keep non-design sectors interested in employing them. If using design thinking as a USP would sustain the wellbeing of the design industry in the next decade, it would be in the best interests of design practitioners to back up the application of design thinking with academic theory if such a gap exists between the two sides. By linking the academics and practitioners’ theories and models those outside design perhaps would understand the discipline better. As a result it could make design a stronger strategic tool and open up even more opportunities for the design industry.

### 2.6. Summary of Chapter 2

The data gathered from the literature review has allowed the researcher to conduct an in depth look at the evolution of design thinking since the 1960s. The evidence has showed that the current form of design thinking emerged from the 1960s when design researchers were defining design as a discipline. Looking further back the origins of design thinking can be traced to the 1860s when American philosopher Pierce introduced his theory of the methodology of science. From the literature review, the origins of design thinking can be clearly seen therefore research question 1 was answered by conducting a literature review.

The literature review also provided evidence regarding the relationships between design thinking and the different terms. Cognitive modelling is the
human ability that allows design activity to take place therefore without it there will be no design thinking as discussed in Section 2.2.2. Creative thinking could be a component that is required for the user to employ design thinking or a bi-product of design thinking as discussed in section 2.2.3 the difference of the two depending on the users and the context of design thinking’s application. From Section 2.2.4 designerly ways of knowing is the framework or knowledge base which designers draw upon to choose the appropriate methods to create solutions or solving ‘ill-defined’ problems. Finally with the literature evidence presented from Chapter 2.2.5 designerly thinking could be seen as an early form of design thinking.
### 2.6.1. Overall progress summary

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Where was the concept of design thinking first articulated?</em></td>
<td>✓</td>
<td>Lit Review (2.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><em>Do academic and practitioner interpret design thinking differently?</em></td>
<td>✓</td>
<td>Lit Review (2.3.1 &amp; 2.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><em>Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</em></td>
<td>✓</td>
<td>Lit Review (2.2.1, 2.3.1 &amp; 2.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><em>Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</em></td>
<td>✓</td>
<td></td>
<td></td>
<td>Lit Review (2.3.1)</td>
</tr>
<tr>
<td>5</td>
<td><em>How is design thinking expressed?</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8 Progress summary after Chapter 2
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>7 Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Does design thinking as incorporated in designing within academia match academic articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>9 Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 9 Progress summary after Chapter 2 (Continued from Table 9)
3.1. **Research methodology**

3.1.1. **Introduction**

This Chapter presents the research methodology and research instrument design for this PhD. The chapter explores and justifies the methodological stance, research methods, sampling techniques and data collection method selected. The chapter also presents the mixed method research instrument design and justifies the design decisions behind it.

3.1.2. **Methodological stance and research approach**

With a starting position developed from the literature review, the research was not neutral or un-biased when compared to the traditional grounded theory research from a positivist viewpoint. There, the researcher is assumed to be an unbiased and passive observer who collects data rather than being a participant in the data collection process (Charmaz, 2006: 5). Furthermore, the positivist viewpoint does not allow the researcher to interact with the subjects, therefore, erases the social context from which the data emerge (Charmaz, 2006: 131-132). The similarities and differences between academic and practitioner views on design thinking were revealed in the findings of the literature review. The different viewpoints between academia and practice highlighted the difficulty when articulating the meaning of design thinking. In order to successfully articulate its meaning; the researcher would need to understand the social contexts that the viewpoints emerged from. These contexts were important as they could be factors that shaped the differences in academic and practitioner viewpoints. Therefore, it would be impossible to accurately articulate design thinking's meaning without fully understanding those contexts.

As a result, the research carried out for this PhD was from a constructivist viewpoint. The constructivist grounded theory acknowledges the researcher as an active instrument in the research, therefore allowing the researcher to interact with the participants to create new knowledge (Charmaz, 2000: 510). It also encourages the participants to share their
experience in their terms; hence, creating the knowledge exchange atmosphere required. The research conducted in this PhD used existing work from academia and practice as a foundation. Therefore, to identify the data that would further the articulation and understanding of design thinking as well as generating new knowledge, an atmosphere that encouraged knowledge exchange was required. This atmosphere would encourage the participants to express their viewpoints freely; doing so would allow the data to emerge from its natural contexts. This would provide opportunities for the research to understand the similarities or differences behind participants’ viewpoints, as a result, clarify and catalogue them to generate new knowledge to add to the existing body of work related to design thinking.

With the methodological stance chosen the next decision to be made was whether qualitative or quantitative data is required for this thesis. Table 10 presents the differences between the two types of data:

<table>
<thead>
<tr>
<th>Paradigm/ Perspectives</th>
<th>Qualitative data</th>
<th>Quantitative data</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does the data represent?</td>
<td>Understanding behaviour from actors’ own frames of reference</td>
<td>Facts/ cause of social phenomena</td>
</tr>
<tr>
<td>Level of control during data collection</td>
<td>Limited, data usually collected in its natural surroundings</td>
<td>High, data collected by obtrusive and controlled measurements</td>
</tr>
<tr>
<td>Subjective or objective</td>
<td>Subjective</td>
<td>Objective</td>
</tr>
<tr>
<td>Should the researcher interact with the data?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Types of data collected</td>
<td>Valid: real, rich, deep data</td>
<td>Reliable: hard and replicable data</td>
</tr>
<tr>
<td>Flexible or fixed?</td>
<td>Flexible</td>
<td>Fixed</td>
</tr>
</tbody>
</table>

Table 10: The differences between qualitative and quantitative data, table adapted from Oakley (1999: 156).

Qualitative research focuses on collecting and analysing information in as many forms as possible. The information gathered is mainly non-numeric and the information tends to be used to focus on exploring in as much detail as possible. Qualitative research aims to create depth with the data rather than quantity or breadth, therefore, the sample size required for this type of research is also smaller. Quantitative research on the other hand focuses on large and representative data sets; in quantitative
research it usually concentrates on numeric information (Blaxter, Hughes and Tight, 2006: 64).

The following objectives were set for this research:

1. Articulate the meanings and understandings of design thinking since the 1960s.

2. Clarify if design thinking is thinking done by designers.

3. Explore the relationship between academic and practitioner application and understanding of design thinking.

With the research objectives set, qualitative research would be the most suitable way of conducting the research. Quantitative research would not be a suitable way to conduct the research as it focuses on numerical information. However the nature of the objectives, using objective one: to articulate and understand the meaning of design thinking since the 1960s as an example, quantitative research would not be suitable as numeric data would not provide the necessary rich deep data required to achieve the objective. Similarly for the other two objectives, quantitative research would not be appropriate because these objectives would require a deep understanding and explore the ‘insider’ perspective (Blaxter et al, 2006: 65) in order to fulfil them.

One of the benefits of this methodology is that it gives the research a flexible approach to use a variety of data collection methods during the research along with a systematic structure to the research (Charmaz, 2006: 2). By employing this methodology the researcher was able to build a systematic research structure that can house the different data collection methods that are planned to be used during the research. As Robson (2002: 166) pointed out a ‘good’ flexible research structure allows rigorous data collection via different methods, therefore, producing rich qualitative data. Furthermore it also maximises the chances of the researcher reaching out to the participants as various data collection methods could be used. The structure also provides guidelines for the
researcher when it comes to designing the research instrument to ensure the data collection methods generate the same type of data.

Along with the rich qualitative data that it could generate, the methodology allows the researcher to discover ideas or concepts that can be used to create hypotheses from the field that can be used to generate theory (Robson, 2002: 191). This is particularly appealing for this study as it allows the researcher to constantly evolve the initial theory and research instrument content throughout the duration of the PhD to integrate and gather the most up to date information.

With the research following the protocols of a constructivist grounded theory approach and generating knowledge with qualitative data; it has been acknowledged that the research conducted would have a certain degree of bias. The bias within the research conducted would likely occurred through the researcher’s prolonged involvement with participants and fieldwork (Robson, 2011: 157) in order to gather useful data to generate new knowledge. The biases occurred in the research will be discussed further in the relevant chapters of this thesis.

3.1.3. Grounded theory an overview

With the research using a constructivist grounded theory approach an overview of the history of grounded theory would provide a deeper understanding of the approach and evidence on why it is suitable.

Grounded theory emerged in the early 60s when sociologists Glaser and Strauss collaborated during their study of dying in American hospitals. In their study the research teams observed how dying occurred in a variety of hospital settings. The data gathered was analysed with an explicit analytical manner and the result was a theoretical analysis of the social organisation and temporal order of dying. Systematic methodological strategies were developed from the research and the strategies developed were adaptable too, leading to social scientists using them in different disciplines and topics. The strategies were articulated in Glaser and Strauss book, *The Discovery of Grounded Theory* (1967). The book provided an articulation of the strategies and developing theories from
research grounded in data rather than deducing testable hypotheses from existing theories. (Charmaz, 2006; 4)

Glaser and Strauss’ work challenged the methodological assumptions during the period. Back then quantitative methods were dominant in the field of sociology and quantitative methods were the only methods that would have validity in the positivists’ viewpoint. As a result of that, they rejected other methods and qualitative methods were seen as impressionistic, unsystematic and biased. However, the methods listed by Glaser and Strauss (1967) were the opposite of what positivists believed qualitative methods to be. In the book the authors proposed that systematic qualitative analysis had its own logic and could generate theory particularly in building abstract theoretical explanations of social processes (Charmaz, 2006, 4-5).

Since the inception of grounded theory in the 60s by Glaser and Strauss, the methods have been further developed and adopted by others. In the late 80s Strauss developed the method further from being just a method of discovery to a method of verification (Strauss, 1987). As a method of verification, Strauss and Corbin’s (1990 & 1998) version of grounded theory differed from the earlier versions that emphasised on the use of comparative methods. Instead their version incorporated new technical procedures. However, Glaser (1992) did not approve this version of grounded theory as he believed the new technical procedures forced data and analysis into predetermined categories, therefore, contradicting the underlying principles of grounded theory. As the development of grounded theory continued, a number of scholars (Bryant, 2002 and 2003; Charmaz 2000, 2002 and 2006; Clarke, 2003 and 2005 and Seale, 1999) moved grounded theory away from the positivism stance that was developed in the works of Glaser and Strauss (1967) and Strauss and Corbin (1990). These researchers’ work showed the continued development of grounded theory and how the method is being adopted by many today (Charmaz, 2006: 8-9). Despite the movement away from the positivism stance grounded theory is still a flexible and validated method of qualitative research.
3.1.4. Research methods

The methods used in the research would be a mixture of qualitative methods such as literature review, interviews, focus group interviews, focus groups and surveys. With the research employing a grounded theory stance, interview is seen as a suitable method to collect data as it encourages an in depth exploration of a particular topic or experience (Charmaz, 2006: 25). Focus groups and focus group interviews are also suitable methods as they both provide the opportunities of in depth exploration of data in the form of interacting and recording opinions from groups of participants (Krueger and Casey, 2009: 7). Online surveys can provide a platform for participants worldwide to take part in the study. The design of the online survey will be based on the questions used for the interviews. These methods will be discussed further in Chapter 3.2.

This research will be multi-method to maximise the opportunities to gather quality data. Tables 11-15 discuss the different methods that could be used to achieve the different objectives and the related research questions:
<table>
<thead>
<tr>
<th><strong>Research objectives</strong></th>
<th><strong>Research questions</strong></th>
<th><strong>Methods</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective 1:</strong> Articulate the meanings and understandings of design thinking since the 1960s.</td>
<td>RQ 1: Where was the concept of design thinking first articulated?</td>
<td>Literature review: Review of literature on design thinking; therefore providing opportunities to identify the data required to establish when design thinking was first articulated. Interviews: Discuss with participants when they think design thinking was first articulated and compare those findings to the literature review findings to gain a more comprehensive answer to the research question.</td>
</tr>
<tr>
<td></td>
<td>RQ 2: Has the meaning of design thinking changed since the 1960s?</td>
<td>Literature review: Identify from literature if the meaning of design thinking has changed since the 1960s. Interviews: Provide the opportunities to interact with research participants to discuss their viewpoints on the meaning of design thinking. Use the findings to identify if design thinking has changed since the 1960s.</td>
</tr>
</tbody>
</table>

Table 11 Research objective 1 and its potential data collection methods
<table>
<thead>
<tr>
<th>Research objectives</th>
<th>Research questions</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective 1:</strong> Articulate the meanings and understandings of design thinking since the 1960s.</td>
<td>RQ 3: Do academics and practitioners interpret design thinking differently?</td>
<td>Literature review: Identify the academic and practitioner interpretations from literature. Interviews: Provide the opportunities to interact with research participants to discuss their viewpoints on the meaning of design thinking, therefore, identifying the similarities and differences in perspectives.</td>
</tr>
<tr>
<td></td>
<td>RQ 4: Can a generic design thinking model be created from academic and practitioner interpretations?</td>
<td>Literature review: Use the findings of the literature review as the basis of a generic design thinking model. Interviews: Using the data gathered by interviews as a basis of a generic design thinking model.</td>
</tr>
</tbody>
</table>

Table 12 Research objective 1 and its potential data collection methods (Continued from Table 12)
<table>
<thead>
<tr>
<th><strong>Research objectives</strong></th>
<th><strong>Research questions</strong></th>
<th><strong>Methods</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective 2:</td>
<td>RQ 5:</td>
<td>Interviews: Question the research participants how they think design thinking is expressed and ask them to provide examples.</td>
</tr>
<tr>
<td>Clarify if design thinking is thinking done by designers</td>
<td>How is design thinking expressed?</td>
<td>Online survey: Use the research question to ask the participants to provide examples.</td>
</tr>
<tr>
<td></td>
<td>RQ 6:</td>
<td>Interviews: Question the research participants about their views on design thinking and design education.</td>
</tr>
<tr>
<td></td>
<td>Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td>Online survey: Use the research question to ask the participants to give their views on design thinking and design education.</td>
</tr>
</tbody>
</table>

Table 13 Research Objective 2 and its potential data collection methods.
<table>
<thead>
<tr>
<th>Research objectives</th>
<th>Research questions</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective 2:</strong> Clarify if design thinking is thinking done by designers</td>
<td><strong>RQ 7:</strong> Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td><strong>Interviews:</strong> Question the research participants about their views on design thinking and use that to answer the research question. <strong>Focus groups:</strong> Use the research question as a discussion theme to gather participants' views on design thinking expression.</td>
</tr>
<tr>
<td><strong>Objective 3:</strong> Explore the relationship between academic and practitioner application and understanding of design thinking</td>
<td><strong>RQ 8:</strong> Does design thinking as incorporated in designing within academia match the academic articulation of the concept?</td>
<td><strong>Literature review:</strong> Identify the academic articulations of design thinking from literature. <strong>Interviews:</strong> Ask for examples of academic design thinking application to compare to the articulations identified in literature.</td>
</tr>
</tbody>
</table>

Table 14: Research objective 2 & 3 and their potential data collection methods.
<table>
<thead>
<tr>
<th>Research objectives</th>
<th>Research questions</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective 3: Explore the relationship between academic and practitioner application and understanding of design thinking</td>
<td>RQ 9: Does design thinking incorporated in designing within practice match practitioner articulation of concept?</td>
<td>Literature review: Identify the practitioner articulations of design thinking from literature. Interviews: Ask for examples of academic design thinking application to compare to the articulations identified in literature.</td>
</tr>
</tbody>
</table>

Table 15 Research objective 3 and its potential data collection methods.
Reliability of the research is gained by triangulation through case study analysis. Case study analysis is a suitable method of checking the reliability of the findings because of its abilities as an evaluation tool within the qualitative research approach as Simons (2009: 16) wrote:

‘Case study was one way of conceptualising an alternative methodological approach to evaluating a particular programme or policy.’

The programme or policy being evaluated here are the findings and data gathered. Finally the findings from the multi-method approach and case study analysis will be validated by seminars with academics and practitioners. These methods will be discussed further in Chapter 3.2.

3.1.5. Data analysis

Using qualitative methods the following types of word data could emerge: written or spoken words, written notes or carefully considered written words. Written words are information that has been transcribed directly; written notes are put together after the event that they purport to describe and carefully considered words are intended for publications. These examples show the different level of abstraction the data can be in (Blaxter et al, 2006: 200–201). Document analysis, content analysis, thematic analysis and case study analysis are likely to be the data analysis methods selected. These are suitable because they provide the basis to generate a theory to explain the findings of the research. Employing these methods allowed conceptual categories to be formed from the data, possible relationships to be identified and a theory to be constructed from the data gathered (Robson, 2011: 489).

During the research data analysis will be conducted at three different milestones; those milestones are: pilot study (Chapter 4), main study (Chapter 5) and checking reliability (case study analysis, Chapter 6. For the pilot study the data analysis method chosen would be thematic analysis or content analysis as the pilot study provided an opportunity to test out the effectiveness of both data analysis methods. For the main study the data analysis methods will be content analysis and thematic
analysis. In general the data analysis conducted will go through coding, identifying patterns and themes and using those found to develop the theory (Robson, 2011: 469). The details of the data analysis methods will be discussed in the respective Chapters.

3.1.6. Sampling techniques

As the findings from the literature review suggested in Chapter 2.5, it appears four common characteristics of design thinking emerged from the findings. With the emergence of these categories, a sampling technique that enabled the research to further the development of these categories in the main study was needed.

Theoretical sampling was a technique that suited the needs of the research. It obtains data to help the research explicate its categories (Charmaz, 2006: 100). It is a strategy that narrows down the focus on emerging categories and as a technique to develop and refine them. Theoretical sampling begins when the research has some preliminary categories to develop. It enables the researcher to check, qualify and elaborate the boundaries of these categories and specify the relations between them. To begin with it helps the research to fill out the properties of a category, therefore, enabling the creation of an analytic definition and explication of it. Later, it may aid the demonstration of the links and relationships between the categories (ibid: 107). In addition, the technique also increases the precision of the categories and explicating the analytic links between categories (ibid: 105).

Theoretical sampling allowed the research to specify the relevant properties of categories; in this case, selecting participants that would provide the valid responses to further the development and identification of existing and new common characteristics of design thinking (ibid: 100-101).

For the pilot study, opportunity sampling was used. Opportunity sampling was selected for the pilot study because it was an internal test for the research instrument, data collection methods and data analysis method selected. The technique enabled the research to select the available
participants within the given time period to carry out the pilot studies efficiently.

3.1.7. The difference between expert and novice

In order to maximise the performance of theoretical sampling as discussed in Chapter 3.1.6, an understanding of the differences between experts and novice is required. With design thinking being a complex phenomenon the most suitable way for this research to move forward is opinions and views of expert design academics and practitioners.

According to Cross (2004: 427–428) who summarised Ericsson et al.’s (1993: 363–406) view, on expertise, to be an expert in any field that person must have done the following:

‘But one aspect that seems agreed from the studies of expertise is that it requires a minimum period of practice and sustained involvement before performance reaches an international peer level of achievement – at least 10 years from first involvement.’

The summary gave a good indication that in addition to time, the accumulation of experience (Cross, 2004: 431) is also vital in the process of becoming an expert. In addition to time spent in a subject area or role and experience; cognitive abilities are also a vital component contributing towards an expert’s development and problem solving abilities. Cross (2004: 430) stated that experts are believed to have the ability of storing larger cognitive ‘chunks’ of information when compared to novices. The ability to store more information is vital to an expert’s capability of recognising underlying principles rather than focussing on the surface features of problems. An example of how an expert’s cognitive abilities provided superior problem solving skills was described in a study conducted by Ho (2001: 27-45). The study investigated into the problem decomposition strategy between novice and expert designers. The study findings showed the expert designer’s choice of design problem decomposing strategy was the exploitation of different domain knowledge. The expert designer used the knowledge to move downwards through the levels of abstraction of design problem to the lowest degree possible.
hence framing and mapping out the problem with accuracy and therefore defining the problem space that he or she would work within. The difference between the expert and novice designers was the level of structure in problem decomposing. The expert designer clearly displayed a greater structure when compared to the novice designer. The structure helped the expert designer to explore and analyse the problem in greater detail whereas the lack of structure of the novice designer restricted the resolution of the solution due to the lack of further exploration of the problem.

From the viewpoint of this research, Ho’s (2001: 27-45) study findings vindicates the choice of the sampling technique and the need for experts as participants. As discussed, design thinking is a complex phenomenon, one that many experts are debating at the moment; from Cross’s (2004: 427-441) and Ho’s (2001: 27-45) research findings it would be reasonable to believe novice designers could struggle to understand the research subject and therefore would be unable to provide valuable qualitative data. However, experts are suitable because of their decomposition strategy and cognitive abilities as those would allow them to frame the research questions into a more defined problem space and as a result they should be able to provide useable qualitative data.
3.1.8. Research approach – multi-methods approach

With the methodological stance of this PhD being constructivist grounded theory, a multi-methods approach as shown in Figure 13 would be the most suitable to move the research forward. It was suitable because the researcher based the inquiry on the collecting of diverse types of data that best provide an understanding of a research problem. The study begins with a broad survey in order to generalise results to a population and then focuses, in a second phase, on detailed qualitative data collection (Creswell, 2003: 21). In this case it was the literature review that was carried out to examine the different theories that were put forward by practitioners and academics on design thinking, therefore, establishing the basis of the enquiry. Then the research moved on to data gathering in the main study.

This will maximise the chances of collecting high quality qualitative data. Furthermore, using this approach would allow the researcher to be
flexible on the choice of data collection methods, as the approach does not confine the researcher to a particular philosophical position prior to the beginning of the research (Plowright, 2011: 7). With this flexibility the researcher can chose the suitable data collection methods for each research question or situation encountered, therefore, allowing the researcher to employ the concurrent triangulation strategy to answer each research question. Using research question 3 as an example, Figure 14 shows how a research question will be answered by this approach:

Data collection method 1: Literature review

Data collection method 2: Interviews/ Online survey

Research question 3: Does the academic interpretation of design thinking differ from that of practitioners?

Data collection method 3: Case studies analysis

Figure 14 Research question 3 answered by multi-methods approach
3.2. Research design

3.2.1. 3 Phases of research

The findings from the literature review suggested that the articulation of design thinking has subtly changed; however, it is the context in which it is being applied that has changed dramatically since the 1960s. In order to keep the research up to date with the developments; the research instrument would need to be constantly evolving as Robson (2002: 191) highlighted. To keep the research moving forward as well as building reliability via triangulation (Plowright, 2011: 141) into the overall outcome of the research, the researcher would carry out the research in three phases. Phase 1 was the literature review. Phase 2 was data gathering via the research instrument. The design of the research instrument will be explained and presented below. The reliability of the data collected is checked by case studies analysis. The case studies analysis will be based on the findings from the research instrument. The findings of phase 1 and 2 will be combined together to create a qualitative data driven theory of design thinking derived from the knowledge of academia and practice. Once the theory has been created the research moves into phase 3. Here, validation studies with academics and practitioners to be carried out to validate the theory. Figure 15 maps out the methodology for the research:
Figure 15 Methodology diagram; the colours represent different stages.
3.2.2. Phase 1 – Literature review

Phase 1 of the research was a selective literature review of design thinking. The selection of literature reviewed consisted of the following: design thinking books written by design practitioners published between 2009-13, research papers related to design thinking from the 1960s to present and literature suggested by the researcher’s PhD supervisors and research participants. The literature review’s purposes were to explore the possible knowledge gaps and to identify principal areas of dispute and uncertainty (Robson, 2011: 52), therefore, provided a point of departure for the research. Literature gathered was reviewed under the following three themes:

- History of design thinking
- Aspects of design thinking
- Claims of design thinking in practice

Under the three themes the literature review provided the following findings: the origins of design thinking, the relationship of design thinking and related terms plus the latest developments concerning design thinking in academia and practice. In addition, it also examined if the meaning of design thinking has changed and provided a portfolio of design thinking case studies. The findings of the literature review formed the basis of the multi-methods research instrument. Using this principle the research instrument was designed to trigger the participants into thinking about design thinking during data gathering.
3.2.3. Phase 2 – Multi-methods research instrument (RI) design

With the use of constructivist grounded theory as the research framework; the research instrument had different forms of media outlets such as: interactive website or presentation to pair with the mixture of data collection methods the research planned on using. The different data collection methods were:

- Focus groups
- Online survey (qualitative)
- Interviews
- Seminar (Focus group interviews)

To keep the data generated by the different data collection methods consistent all methods will have the same content the only difference would be the delivery and visuals. For example, the questions in the online survey and the interview are the same; the difference will be how the participants answer the questions. By using the same content over all the data collection methods the researcher will have a reasonable degree of control over the types of data generated, therefore, building ecological validity (Plowright, 2011: 30) into the research. Reliability of the research would be achieved by case study analysis. Validity of the research would be achieved by the validation studies to be conducted with academics and practitioners.

The key literature presentation showcased the key milestones of design thinking development from academic and practitioner viewpoints in the past five decades. The research instrument does not critique who is in the right or the wrong. It puts together a timeline of design thinking development. By showing the participants the history of the process it should trigger them into thinking about their own definitions of design thinking. The researcher would be able to evolve the current definition of design thinking from the initial theory via qualitative data generated from the research instrument. Figure 16 shows an example of the key literature presentation. For the full presentation please refer to Appendix 3.
Figure 16 Example slides from the research instrument presentation, February 2013
3.2.4. Phase 2 data collection methods

The following sections of this Chapter presents the four different data collection method selected to work with the research instrument. Case studies analysis is not part of the research instrument. It would be used after the research instrument finished gathering data.

3.2.4.1. Case study analysis

Case studies analysis was the method chosen to check the reliability of the data and findings as discussed in Chapter 3.2.4; the programme or policy being evaluated here were the findings of the research.

The specific type of case studies would be used for evaluation and validation is ethnographic case studies. Ethnographic case studies use qualitative methods to allow the researcher to gain close-up descriptions of the contexts and are concerned to understand the case in relation to a theory or theories of culture (Simons, 2009: 22). The theories of culture that the research was trying to understand in this case would be the findings and data gathered by the research instrument. Using this principle the data gathered will be compared to those in the case studies therefore, identifying if what the participants said was the same as what they would do in their natural environment. Doing so would provide the reliability in the research and the opportunities to discover previously unknown theories as the case studies analysis will act as the final step of the triangulation for the research.

Case studies analysis had the following advantages: flexible; neither time-dependent nor constrained by method and useful for exploring and understanding the process and dynamics of change. Here, the dynamics of change could be the difference between what the researcher was being told during interviews and what the participants do in their natural environments. Additional advantages included the ability to document multiple viewpoints and perspectives plus its capability to explore a subject in depth in terms of contexts when coupled with qualitative methods (Simons, 2009: 23). The advantages above makes case studies
analysis a suitable method to bring readability into the research and help further gather rich data.

Despite its strengths as a validation method, case studies analysis also has its limitations. One of its possible limitations was related to subjectivity of the researcher. It was a potential problem because involving personal emotions during the research could affect the reliability (Simons, 2009: 24, 90). In order to avoid the validity of the method being threaten and remain objective, the analysis categories used during case study analysis were based upon the findings of the main study. Another possible limitation of the method was its inability to capture the reality as lived or experienced in the form of report writing. To counter the issue highlighting the timing, contexts and condition of the study could help bring out the relevance and significance of the data (Simons, 2009: 24).

3.2.4.2. Focus group

Focus group was a data gathering method selected because of its ability to explore and examine what the experts’ views on design thinking. This method enabled in-depth discussions to be held in a controlled environment. As the discussions focused on a specific area of interest, therefore, creating opportunities to discover hidden insights via discussing the topic in great detail as the participants would be sharing their personal experience, viewpoints and knowledge (Liamputtong, 2011: 4-5). Focus group fitted well with the methodology chosen as it generates data via exchange between participants.

Holding focus groups for design practitioners and academics to take part in would provide chances to obtain detail understanding of the numerous interpretations on design thinking that the participants have in their minds. Therefore, gathering insights into the differences or similarities between the two sets of theory from the experts’ perspective (Krueger and Casey, 2009: 19) hence gathering valuable qualitative data.

Despite its advantages, focus group also had a few disadvantages. One of the potential issues was participant related. Within a group of participants there could be a dominant individual, whose ideas or concepts could
influence the behaviour of the group (Kruger et al, 2009: 15). The dominant individual usually could be spotted by pre-session small talk. To counter this problem the moderator could arrange the dominant individual to sit next to the moderator and exercise control via the use of body language. Should the body language tactic failed, then the moderator could verbally shift the focus by asking others to contribute towards the topic. The verbally shifting tactic could also work on shy participants by encouraging them to speak out their ideas (Kruger et al, 2009: 100). Another disadvantage was the logistics of hosting focus groups. Relating to the logistics issue a focus group for market research is traditionally made up of ten to twelve participants; however, this research was not market research it was suggested that the size of the focus group used here should be five to eight participants. Should focus groups be conducted the aim would be to recruit a minimum of four design thinking experts and conduct mini focus groups. Mini focus groups were suitable from a logistic point of view as the participants' number required was not as high as a traditional focus group. Furthermore, it could be extremely hard to recruit eight design thinking experts to take part in a focus group so the mini focus group format would be the most efficient way of data gathering. Despite its advantage from the logistics point of view, mini focus group also has its disadvantages. For example one of them would be the limited range of experience between participants due to the lower number of participants. This could be a problem in other research that requires larger sample sizes. But for this study it would be less of a problem due to the sampling technique selected (Kruger et al, 2009: 67–68).

The framework that the focus group based on would be symbolic interactionism (Liamputtong, 2011: 16). The symbolic interactionism framework emphasises the essence of meaning and interpretation as each member of the group is encouraged to share their views and then through interaction and discussions with others to make sense of social phenomena. For this PhD, the interaction between the experts would allow all the different viewpoints on design thinking to be used for creating the ‘shared stocks of knowledge’. (Holstein and Gubrium 1995: 108)
71) By creating the ‘shared stocks of knowledge’; the data gathered could be used to check the reliability of the initial theory.

3.2.4.3. Interview (semi-structured)

Interviews were a flexible way of gathering data. It is also a method that is widely used in grounded theory studies. One of the advantages of using interviews as a data collection method would be direct interaction with the participant. Therefore, gathering first hand data rather than second hand data. Direct interactions with participants enabled a better understanding of the data and changed the questions accordingly. However, interviews also have their disadvantages. Despite being flexible, interviews could be time consuming. From a qualitative research viewpoint any interviews with the length under thirty minutes are unlikely to provide useful information or data. To ensure the quality of the data gathered, the minimum length of the interviews would be an hour long (Robson, 2011: 280–281). To prevent the interviews going off track, they would be semi-structured.

With a multi-methods approach, semi-structured interviews were the most suitable choice. Semi-structured interviews were chosen based on the factor that the interview schedule allows introductory comments. Here, it meant the research instrument presented by the researcher. This would enable the researcher to set the boundaries of the interview and introduce the topic to the participant (Robson, 2002: 278). Furthermore, this interview framework would give the researcher a good balance of guidance to shape the session and the freedom for the participants to express their viewpoints. Therefore, creating a knowledge exchange atmosphere (Charmaz, 2000: 510), which fits well within the chosen methodology.

3.2.4.4. Online questionnaire

Online questionnaire was another data collection method. One of the advantages of the method was it being an extremely efficient way to gather data from a large group of participants. It could increase the
chances of getting in touch with experts worldwide. It would also be relatively inexpensive compare to hosting a focus group on campus or travelling to interviews. Furthermore, it could be an extremely speedy way of gathering data with a typical data collection period of less than 20 days. It could provide a quick turnaround if needed. Finally, online questionnaires could be completed anonymously therefore allowing the participants to express themselves freely. (Robson, 2011: 240–241 and 248–249)

Online questionnaires also have their disadvantages. One of the disadvantages of this method would be the quality of the data. The data collected could be affected by the characteristics of the participants. It means the participants’ personal experience; knowledge and motivations could affect the quality of the data. To counter the potential issue, the online questionnaire would be paired with a presentation regarding design thinking. The purpose of the presentation was to trigger participants into thinking about their views on the subject. The presentation on the research website acts as the alternative for the lack of interaction between the researcher and the survey participants. In addition, the presentation and the website also house the instructions for the survey and the summary of the research.

Another potential disadvantage would be a low response rate; this could be a serious problem as it could affect the quality and quantity of the data. This could be a problem that is likely occur, the sampling technique selected for the research should minimise its effects on the research. Another possible problem with this method could be the reliability of the data collected. To ensure the data is reliable, here, it means the data gather would be consistent to those collected through semi-structured interviews and focus groups; the questions used in the online questionnaire would be the same as those used in the semi structure interview. This is to ensure the consistency and quality of the data gathered. Reliability of the data gathered was achieved by the multi-methods triangulation approach (ibid: 238–241, 248–249).
3.2.4.5. Seminar (focus group interviews)

Seminar was a data collection method intended for a large audience. An example of where this method could be deployed would be if an entire design consultancy or academics from a design department agreed to take part in the research. In order to gather data, the seminars would run similarly to focus groups. The structure of the seminars would be based upon the structure used for focus groups. As it would be extremely time consuming to interview all participants, to gather the data required focus groups interviews would be conducted. The participants for the interviews would be chosen by theoretical sampling and the information for that will be gathered by an online survey that participants fill out before the seminar takes place.

Focus group interviews were a suitable method in this situation as time could be an issue. By conducting focus groups interviews instead of running focus groups, it could avoid the risk of the research being time consuming therefore, lowering the chances of participants agreeing to take part. In addition, running focus group interviews could ensure all selected participants get their chance to speak about their views. In a focus group it might not be possible due to dominant individuals. The advantage of this method would be allowing the researcher to reach a wide range of audience within an organisation. Furthermore, this method provides opportunities to uncover factors that influence opinions in complex topics. Here, it could be particularly useful as it could provide data on an organisation’s view regarding design thinking.

Focus group interview would only be used should the chance to conduct research with an entire organisation arise. This method would not be suitable when the participants’ numbers are low or when it is possible to conduct interviews; as interviews could provide higher quality data (Kruger et al, 2009: 19–20).
3.3. Summary of Chapter 3

This Chapter discussed the methodological stance of the research, provided an overview of the development of grounded theory and an overview on design expertise. Doing so provided the reasons why the constructivist grounded theory was the most suitable way to conduct the research. It also discussed the sampling techniques: theoretical sampling and opportunity sampling. Theoretical sampling was selected as it was the most effective way to ensure expert participation and recruitment. Opportunity sampling was selected as it was the most effective method to recruit pilot studies participants internally. Furthermore, the chapter also looked at the multi-methods research approach, how this approach is suitable for the research and how reliability is achieved for the data collected.

Finally, the Chapter provided a detailed look at the three phases of research, what the literature review can provide and the starting point of the data gathering. In addition to that the chapter explore the differences between the data collection methods as well as presenting the research instrument design.
Chapter 4 - Pilot studies and updated research instrument
4.1. Introduction

This chapter presents the findings from the pilot study.

4.2. Aim of pilot study

The aim of the pilot study was to test the effectiveness of the data collections methods, gain a better understanding of the research instrument design and a better understanding of how to conduct content analysis.

The pilot studies were conducted between April–May 2013 within the Loughborough Design School. The sample size of the pilot studies was 17 participants. They were selected by opportunity sampling as discussed in Chapter 3.1.6.

4.3. Pilot interviews

4.3.1. Participants and study

Table 16 shows the background of the pilot interview participants:

<table>
<thead>
<tr>
<th>Participants</th>
<th>Roles</th>
<th>Background/expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>Design School administrator</td>
<td>Prior joining the department worked in the engineering and defence sector for 20+ years</td>
</tr>
<tr>
<td>Participant 2</td>
<td>Lecturer</td>
<td>Industrial/product design, design studio owner</td>
</tr>
<tr>
<td>Participant 3</td>
<td>2nd year PhD student</td>
<td>Design engineer and ergonomics</td>
</tr>
<tr>
<td>Participant 4</td>
<td>3rd year PhD student</td>
<td>Industrial / product design, additive manufacturing</td>
</tr>
</tbody>
</table>

Table 16 Participants of the pilot interviews

Four pilot interviews were conducted and they were approximately an hour long. They followed the programme:

1. Design Thinking Survey part 1: Prior to the presentation the participants fill in part 1 of the survey that records their details and provides an introduction to the running order of the session.
2. Presentation by researcher: ‘What is Design Thinking?’ a presentation on the origins, history of design thinking in literature along with a portfolio of case studies of the processes' application.

3. Design Thinking Survey part 2: After the presentation the participants finish the interview session by filling in part 2 of the survey.

Figures 17-19 provide examples pages of the Design Thinking survey.
PART 1
Please fill in part 1 of the survey before the start of the presentation.

1. Your details and occupation
   This data is collected to allow the researcher to put the participants into the correct groups during data analysis.

   a) Your name: 

   b) What is your occupation and who do you work for?

   c) Which field does your employer belong to?

   d) How many years have you been working in this field?

   e) Your email address:

PART 1 CONTINUED
2. Your knowledge towards design thinking prior the presentation

   a) Before participating in this session, have you heard of design thinking or applied design thinking before?

   b) What do you think design thinking is?

   c) Please give details of your previous experience of using design thinking.

END OF PART 1
Thank you for completing Part 1. Please complete Part 2 after the presentation.
PART 2

Please write your name above and answer the following questions.

1. Your views on design thinking

   a) After the presentation could you write down what you believe design thinking is?

   b) Do you believe there are any differences between academic and commercial applications of design thinking?

   c) Could you write down those differences?

2. How accurate was design thinking represented in this presentation?

   a) Did the literature in this presentation provide an accurate overview of design thinking since the 1960s?

   b) If not could you point out which decade was inaccurate?

   c) Please give examples that you believed should have been included in the decade that you identified as inaccurate.
3. Applications of design thinking

Common factors:
1) ‘Game changer’
2) Expert participation
3) Competitive advantage
4) Revolutionary

a) Do you agree with the common factors listed in the presentation?

b) Could you give examples of you using design thinking?

c) In addition to the four common factors in the presentation could add other common factors shared by your experience of using design thinking?

END OF SURVEY

Thank you for participating in this interview and completing the survey. You may be contacted in the near future for further interviews or other research studies.

For the latest development of the research please visit:
www.lboroDResearch.ac.uk
The pilot interviews were conducted on location with the participants. However, should the interviews be conducted on Skype over the internet, the interviews will be done according to the following programme:

Arrange an appropriate time for the interview to take place; then an email with two web links will be sent to the participants and ask them to do the following:

1. Fill in Design Thinking Survey part 1, the researcher will host part 1 of the survey online (hosted on Survey Gizmo with invited access only). The participant can complete part 1 before viewing the presentation and conducting the interview.

2. After filling in part 1 of the Design Thinking Survey, go to LboroDTresearch.co.uk and view the ‘What is Design Thinking?’ presentation. The web presentation is coupled with an audio recording and the transcript of the presentation. This is to minimise the effect of unable to present it to the participants in person.

Once the two steps have been done, the interview will take place using the questions in part 2 of the survey and the responses will be recorded.

With the presentation taking up to twenty minutes of the one hour session the researcher estimates the Skype interviews to be shorter by up to fifteen minutes in comparison to the trials.

4.3.2. Findings

The pilot interviews yielded the following findings:

- The participants responses to the questions suggested that the ‘What is Design Thinking’ presentation performed as expected. It managed to trigger the participants into thinking about their views and understanding of design thinking.

- From Design Thinking Survey part 1, rephrased question 1c: ‘which field does your employer belong to?’ the participants felt it was oddly phrased. More options were needed for question 2a: ‘before participating in this session, have you heard of design thinking or
applied design thinking before?’ the participants thought some examples could be useful to help them answer the question.

- From Design Thinking Survey part 2, rephrased question 2: ‘how accurate was design thinking represented in this presentation?’ the participants found it a hard question to answer; they suggested it needed redeveloping.

4.4. Pilot focus group

4.4.1. Participants and study

Table 17 shows the background of the pilot focus group participants:

<table>
<thead>
<tr>
<th>Participants</th>
<th>Roles</th>
<th>Background/expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 5</td>
<td>Research associate</td>
<td>Interaction and user centred design</td>
</tr>
<tr>
<td>Participant 6</td>
<td>Research associate</td>
<td>Sustainable design</td>
</tr>
<tr>
<td>Participant 7</td>
<td>Research associate</td>
<td>Sustainable design</td>
</tr>
<tr>
<td>Participant 8</td>
<td>3rd year PhD student</td>
<td>Sustainable design</td>
</tr>
</tbody>
</table>

Table 17 Participants of the pilot focus group

The difference between the focus group and interview presentation were the separation of the case studies and overview of literature. The reasoning behind those was to trigger the participants into discussing the topics according to the running order of the focus group. This should have allowed the researcher to maintain control over the discussions and identifying key trends during data analysis.

The chosen environment of the focus group was one of the meeting rooms within the Design School. As the focus group only contained five people including the researcher, the space provided by the meeting room was sufficient. During the focus group the participants were offered chances to provide feedback for improvements. The focus group session was approximately two hours long. Figure 20 shows the proceedings of the pilot focus group.
4.4.2. Findings

The pilot focus group yielded the following findings:

- Participants commented on the lack of an introductory activity, they suggested it would be useful to have one as it could help warm up the participants and avoid creating a ‘un-chatty’ environment for the session.

- The participants found the content of the presentation suitable. However, the participants believed the delivery of the presentation needed improving. They suggested adding case studies to help...
contextualise design thinking. Furthermore, they also suggested adding examples for the concepts of abduction, deduction and induction to help participants understand them. Finally they also suggested shortening the presentation.

- Provide a more ‘chatty’ environment, the moderator needed to talk less.
- Take away the aspect of making the participant write things down on paper; instead record the whole session rather than just parts of it.

4.5.   Pilot seminar

4.5.1. Participants and study

Table 18 shows the background and expertise of the participants who took part in pilot seminar.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Roles</th>
<th>Background/expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 9</td>
<td>1st year PhD student</td>
<td>Industrial/ product design, prior starting the PhD worked at a British vacuum company</td>
</tr>
<tr>
<td>Participant 10</td>
<td>2nd year PhD student</td>
<td>Industrial/ product design</td>
</tr>
<tr>
<td>Participant 11</td>
<td>1st year PhD student</td>
<td>Industrial/ product design</td>
</tr>
<tr>
<td>Participant 12</td>
<td>1st year PhD student</td>
<td>Ergonomics</td>
</tr>
<tr>
<td>Participant 13</td>
<td>2nd year Masters student</td>
<td>Industrial design and engineering</td>
</tr>
<tr>
<td>Participant 14</td>
<td>3rd year PhD student</td>
<td>Art and design, prior starting the PhD worked as an art teacher for 20+ years</td>
</tr>
</tbody>
</table>

Table 18 Participants of the pilot seminar

The seminar was conducted after the focus group. As a result, the research instrument was updated according to the feedback given. The literature review findings and case studies were merged together as they were originally. The visuals of the presentation were updated with the addition of a timeline at the bottom of the slides; however, the content stayed the same. Additional updates of the research instrument included
an updated Design Thinking Survey and making part 1, participants' experience information gathering part of the survey available online by hosting it on Survey Gizmo. Figures 21-22 are screenshots of the survey online.
Figure 21 Screenshot of the participant experience survey
Figure 22 Screenshot of the participant experience survey
The proceedings of the seminar were the following:

1. Participants filled in part 1 of the Design Thinking Survey two days before the seminar took place.

2. Introduction to the seminar

3. Presentation: What is Design Thinking? – 30 minutes

4. Questions and answer session – 20 minutes

5. Design Thinking Survey part 2 – 20 minutes

The estimated time for the session was one hour, thirty minutes. Having the participants fill in the survey beforehand allowed a longer time slot for presenting as well as a longer Q & A session. Finally, this also provided a chance to have an educated guess as what to kind of questions to expect from the audience. Figure 23 shows examples of the updated presentation. For the full presentation please refer to Appendix 4.
1967

"The process of design is the translation of information in the form of requirements, constraints, and experience into potential solutions..."

John Luckman

1970s

60%

85%

Experts

A multidisciplinary team of nurses, staff engineers, and designers

Drivers

NHS cost-cutting and effort to standardise hospital equipment

Introductory evidence-based research process for product design

Impact

Up to 85% of UK hospitals still use the bed design (RCA, 2012)

Events in 1970s

Continue to define design as a discipline

Design as the third area of education

Empirical evidence suggests design thinking's existence

1973

"There is no definitive formulation of a wicked problem."

Ivan W. J Bithel and Mervin M. Webber

Figure 23: Example slides of updated presentation, April 2013
4.5.2. Findings

The pilot seminar yielded the following findings:

- The participants believed the literature review findings part of the ‘What is Design Thinking’ presentation was too text heavy. They believed it would be easier to understand the content with a summary of the findings rather than just quotes.

- A participant suggested further updates to the visual of the presentation to make the four common characteristics easier to understand.

- The case studies of design thinking application enabled the participants to understand the topic better.

- Should not have made the participants write anything; record the session instead.

4.6. Online survey and website testing

4.6.1. Participants and study

Table 19 shows the background and expertise of the participants who took part in the interactive website trial.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Roles</th>
<th>Background/expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 15</td>
<td>3rd year PhD student</td>
<td>Sustainable design</td>
</tr>
<tr>
<td>Participant 16</td>
<td>1st year PhD student</td>
<td>Industrial/ product design</td>
</tr>
<tr>
<td>Participant 17</td>
<td>3rd year PhD student</td>
<td>Industrial/ product design and additive manufacturing</td>
</tr>
</tbody>
</table>

Table 19 Participants of the website trials

The website tests were conducted from April–May 2013. The aim of this was to make sure the website’s functions (media player, slide show and feedback form) were performing as designed. The website was built on the HTML 5 format; therefore, it was necessary to test its functions as the format is not supported by some older internet browsers. Furthermore, this also provided a chance to test the reliability and compatibility.
between the online survey host provider (Survey Gizmo) and the website. The presentation and the survey were exactly the same as the other three research instruments. The participants were invited to conduct the trials in their own time and their responses were recorded via the online version of the Design Thinking Survey. The overall time required for the participants to view the presentation and fill in the survey should be no longer than 35 minutes. Figures 24-26 are some screenshots of the website.
Figure 24 Screenshot of the website’s home page
What is design thinking?

The purpose of this presentation is to trigger and encourage participants to think about what they believe design thinking could be, in order to do so the presentation provides a summary of the history of design thinking and a portfolio of case studies that claimed to be using design thinking.

It is important to remember that this presentation is not stating who is correct or wrong regarding views and aspects of design thinking nor presenting the definitive view of design thinking. Its purpose is to present the views and aspects which are selected from literature published by academics and practitioners to represent the event of the past five decades and the origins of design thinking.

For the presentation transcript press the button below to download.

Presentation transcript download

Introduction

When you are ready press play for audio. The presentation is an audio play.

* This presentation is not stating who is correct or wrong regarding views and aspects of design thinking nor presenting the definitive view of design thinking. Its purpose is to present the views and aspects which are selected from literature published by academics and practitioners to represent the event of the past five decades and the origins of design thinking.

Audio player

Press play for audio

Last updated on 28th June 2013

This site is best viewed in Chrome, Firefox, IE and Safari

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Figure 26 Research website contact page
4.6.2. Findings

The pilot study yielded the following findings:

- The functions of the website performed as expected.

- From the study, it was identified that older versions of Internet Explorer (e.g. in most cases the Internet Explorer 8) did not display the website in the correct ratios. As a result of this discovery, a note will be put at the bottom of the website to provide information for the most suitable browsers to view the website in.

- Record the voice over for the presentation again as the timing was out of sync with the presentation visuals.

4.7. Data analysis of pilot studies

4.7.1. Process used

The data collected from the pilot studies were coded manually. While it would have been beneficial to practice conducting content analysis on the Nvivo 10 software, however, due to the relatively small volume of data gathered it would have been too time consuming. The purpose was to double check the effectiveness of the research instrument in terms of data gathering and generating as well as practice using content analysis.

The research also intended to employ thematic analysis as one of the data analysis methods; however, it was not practised during the pilot study. This was because comparing to content analysis, thematic analysis was relatively straightforward as it did not require three phases of coding. Being less complex meant thematic analysis could be adopted into the analysis relatively quickly when needed. However, it would not be the case for content analysis; therefore, it was decided to use the pilot study as an opportunity to practise it.
4.7.2. Data coding

The content analysis began with open coding. For open coding, the initial codes were based on the four known characteristics of design thinking from literature:

- Driver
- Experts
- Processes
- Impact

Using these four common characteristics, the open coding process identified any codes or keywords that fitted into the following categories. Those were put into the category that they belonged to. Any new or unknown ones were put on the list of possible new categories. Table 21 shows the results of the open coding process:

<table>
<thead>
<tr>
<th>Driver</th>
<th>Experts</th>
<th>Processes</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Designer (9)</td>
<td>Method/methodology (10)</td>
<td>Solutions (3)</td>
</tr>
<tr>
<td>(3)1</td>
<td>Non-designer (4)</td>
<td>Process (9)</td>
<td>Innovate/innovation (4)</td>
</tr>
<tr>
<td>Social (1)</td>
<td>Academia (1)</td>
<td>Approach (2)</td>
<td>Product (3)</td>
</tr>
<tr>
<td>Economics (1)</td>
<td>Practice (1)</td>
<td>Application (3)</td>
<td>Meaningful outcomes (1)</td>
</tr>
<tr>
<td>Environment (1)</td>
<td>Knowledge (1)</td>
<td>To solve (2)</td>
<td>Case studies (1)</td>
</tr>
<tr>
<td></td>
<td>Commercial industries (1)</td>
<td>Problem solving (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineering (1)</td>
<td>Thinking/thought (6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ergonomics (1)</td>
<td>Evidence based (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multidisciplinary team (1)</td>
<td>User centred (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable product design method (1)</td>
<td></td>
</tr>
</tbody>
</table>

Table 20 Open coding results for pilot studies April – May 2013

After the open coding process the analysis moved on to the axial coding process on the list of possible new categories. The purpose of this was to mark out new categories that were worth developing further and looking out for when the actual data-gathering phase began. From the axial coding phase one new category that was worth moving forward with as

---

1 The number next to the code shows the frequency of which the code occurred from the data gathered by the research instrument.
well as a handful of other possible new categories appeared from the data. The category that was worth further investigation was:

- What is a traditional/non-traditional design problem?

With this category being related to the contexts of the problems in which design thinking was being applied to seek solutions; further development and understanding of this category could lead to a better overall understanding of the data gathered.

The following possible new categories were also identified during axial coding:

- Problem space to solution space
- Outside normal design processes or projects
- Design activity
- Stages of innovation
- Rigour required in research
- Risk taking
- Reframing
- Outcome

4.7.3. Effectiveness of research instrument

From the analysis carried out, the research instrument showed it was performing as it should. The four different data collection methods generated codes that supported the four initial categories, therefore, identifying different ways to reinforce them. The codes were mainly generated by interviews, focus group and seminar. The online survey did not generate as many. However, that was due to the fact that the online survey’s pilot studies were mainly testing the technological functionality of the survey and research website rather than generating data.
The research instrument also generated a list of possible categories. One of the categories that was worth further investigating into when the actual data collection begins. Overall the research instrument performed well. From the pilot studies, interviews and online survey were selected as the data collection methods for the main study. They were selected because they were the most effective in terms of time required and the amount of data gathered. Focus groups and seminars were dropped because of the concerns over resources required (research budget and suitable hosting venues) and participants’ availability.

4.8. Research instrument updates, May 2013

This following section of this Chapter describes the updates that were brought into the research instrument from the feedback gathered during the pilot studies. Figures 27-31 present the updated research instrument presentation developed from the findings of the pilot study. The examples here are from the 1960s part of the presentation. The improvements are discussed in details after the figures. For the full presentation please refer to Appendix 5.
Figure 27 RI update 1: Time line using case studies used in the presentation
Events in the 1960s

- Design Methods Movement
- Defining design as a discipline
- Emergence of design thinking as it is understand today

Figure 28 RI update 2: Events of the decade
"(...) the process of designing involves analytical, and creative, objective and subjective phases. (...) Design is thus a very complicated business, involving contrasting skills and a wide field of disciplines. (...)"

Bruce Archer, 1965

"The process of design is the translation of information in the form of requirements, constraints, and experience into potential solution [...]"

John Luckman, 1967

Figure 29 RI update 3: Literature from the decade
Case study 1: The King’s Fund Hospital Bed 1963 - 1975

Figure 30 RI Update 4: Redesigned case study introduction slide
Figure 31 RI update 5: Updated four common characteristic slide
1. The ‘timeline’, a feature added into every slide starting from the 1960s slide. This was added as a result of feedback from the pilot study pointing out the previous versions’ lack of visual impact. Other purposes of the timeline included keeping participants interested and acting as the progress indicator.

2. ‘Key events of the decade’ is the list of significant design thinking events that occurred during the decade. The list’s purpose is to give the participants an overview of the development of design thinking in that decade.

3. ‘Key literature quotes’ is the list of three quotes from literature that provided evidence of the development of design thinking in the decade. When compared to the earlier versions of the presentation (see Appendix 3 and 4) the current version has fewer quotes on this particular slide. The reasons behind cutting down the number of quotes were the following:

   - Improved trigger mechanism; the earlier versions gave away too much information to start with as some of the participants from the pilot study suggested. They commented on the amount of information they have to process in a short amount of time leading them to spend less time identifying their definition of design thinking.

   - Having less quotes also minimised the chance of the participant being affected by the information given to them in the presentation.

   - Should the participants feel the need to have more literature material a full transcript is available on the research website.

4. Case studies portfolio visuals had been updated.

5. The four characteristics were presented as before; however, a picture of the product of the case study is available at the bottom.

Along with the updated visuals, a new case study was added into the case study portfolio. The case study added was the Mothercare Via multibuggy designed by Sebastian Conran, then the head of hard-goods design team at
Mothercare (SCA, 2013). For a detailed breakdown of the case study please refer to Chapter 2.4.3.

4.9. Interview schedule update, May 2013

As Chapter 4.7.2 shown one of the new characteristic of design thinking that was identified and emerged in the pilot study was:

- What is a traditional/non-traditional design problem?

As a result, new questions on this theme were added into the interview schedule. In addition, questions regarding the literature presented were also added. This was to ensure the research instrument was accurate and up to date just in case the existing material missed any new literature. Figures 32-33 show the additional sections on the schedule. For the full interview schedule please refer to Appendix 6.
Figure 32 Additional questions on literature and design problems

1. How accurately was design thinking represented in this presentation?
   a) Did the literature in this presentation provide an accurate overview of design thinking since the 1960s? Circle the answer: Yes, No, I don’t know.
   b) If not could you identify where the inaccuracy was? Circle the answer:
      - 1960s
      - 1970s
      - 1980s
      - 1990s
   c) Please give examples that you believed should have been included and where they should be in the timeline if possible.

2. Can you define a traditional design problem? Circle the answer: Yes, No.

3. Please write down your definition of a traditional design problem.
c) Can you define a non-traditional design problem? Circle the answer

Yes  No

d) Please write down your definition of a non-traditional design problem.

Figure 33 Additional questions on design problems
4.10. Summary of Chapter 4

Chapter 4 presented the findings of the internal pilot studies for interviews, focus group, seminar and trials of the interactive website. From the pilot studies, areas of improvement for all data collection method procedures and the visuals of the research instrument were identified. In addition, a new category/ characteristics of design thinking were identified from the data analysis:

- ‘Design problems’, traditional or non-traditional

This common characteristic had the following meaning: it described the nature of the problem identified.

The data gathered from the pilot studies were analysed by content analysis and the newly identified theme also provided evidence that the research instrument was effective in triggering the participants into thinking about design thinking and gathering useful data. Finally from the findings, interviews and online survey were selected as the methods for the main study as they were the most effective.
### 4.10.1. Overall progress summary

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Where was the concept of design thinking first articulated?</td>
<td>✓</td>
<td>Lit Review (2.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do academic and practitioner interpret design thinking differently?</td>
<td>✓</td>
<td>Lit Review (2.3.1 &amp; 2.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.2.1, 2.3.1 &amp; 2.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.3.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. How is design thinking expressed?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table 21 Progress summary after Chapter 4
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td></td>
<td></td>
<td>✓</td>
<td>Lit Review (2.2.1.&amp; 2.3.1)</td>
<td></td>
</tr>
<tr>
<td>8. Does design thinking as incorporated in designing within academia match academic articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 22 Progress summary after Chapter 4 (Continued from Table 22)
Chapter 5 - Main study
5.1. Introduction

This Chapter presents the findings from the main study. The data being analysed was collected by interviews and online survey. The data collected was analysed by thematic analysis and content analysis. From the analysis, additional common characteristics of design thinking were identified. In addition, the academic’s and practitioner’s consensus definitions of design thinking were developed from the data collected. The Chapter also presents findings regarding how design thinking is expressed and mapped them according to the common characteristics.

5.2. Data collection methods used

The data collection methods used was interviews and online questionnaires. Those two were the most effective methods for the planned data collection period between June – December 2013.

5.2.1. Data collection – Interviews

A total of 13 interviews (6 academics and 7 practitioners) were conducted during the data gathering phase of the research. The participants for the interviews were selected by theoretical sampling and contacted via email, LinkedIn and JISC Mail PhD Design Forum. The interviews were semi-structured as discussed in Chapter 3.2.4.3; the interviews conducted followed the guideline proposed by Robson (2011: 285-287). The questions used in the interview were designed according to the findings of the literature review and pilot studies. The questions were designed to be adaptable and open-ended to allow the interviewees to express their viewpoints freely.

As part of the multi-method research instrument it followed the following schedule:

1. Once a suitable time for both parties was agreed upon the participants were asked to fill in the ‘participant experience survey’ online before the interview, the link was sent to them via email. The purpose of the survey was to identify the participants’ background, expertise, their knowledge and
understanding of design thinking. The figure below is a screen shot of the survey online. For the full survey please refer to Appendix 7.

Figure 34 Screenshot of the participant experience survey, May 2013

2. Once the survey has been completed the participants were asked to view the ‘What is Design Thinking’ presentation (for example slides see chapter 4.8, full presentation available in Appendix 5) on the research website (www.lborodtresearch.co.uk).

3. The next stage was to conduct the interviews. The majority of the UK based interviewees took part in face to face interviews and all non-UK based interviewees took part in Skype interviews. All interviews’ structures were based on the interview schedule shown in chapter 4.9, for the full interview schedule please refer to Appendix 6. The following pages will give some example pages of the interview notes taken using
the interview schedule with participant A-27. Full interview notes of participant A-27 is available in Appendix 10.

4. All interviews were recorded on tape and all interviews were transcribed into Word documents then put into Nvivo 10 ready for coding and data analysis.

Figure 35 Participant A-27 interview notes example, June 2013
5.2.2. Data collection – online survey

A total of 43 online survey responses (30 academic and 13 practitioners) were collected during the data gathering phase of the research. The participants for the online survey were recruited by opportunity sampling with a theoretical approach. While the sampling technique used was different the technique discussed in Chapter 3.1.6 (theoretical sampling was intended to be used for all data collection methods); from the pilot studies, it appeared that opportunity sampling would be more suitable for
the online survey. To minimise the effect of opportunity sampling yielding un-useable data; the participants were recruited with a theoretical approach. Here, it means the survey was only advertised on the following online platforms: JISC Mail PhD Design Forum, Design Council LinkedIn page, UK Industrial Design LinkedIn page, IDSA LinkedIn page, Design Thinking LinkedIn page, Design Thinking Network to maximise the chance of exposing it to qualified participants.

The following message was composed for recruiting participants:

Calling interested participants!

Investigating the contrast in understanding/ application of design thinking from academic and commercial perspectives.

The aim of my PhD is to identify the possible knowledge gap that exists between academics’ and practitioners’ theories of design thinking. In order for the research to move forward I will require experts' opinions and views on the theories and latest developments in design thinking. I am writing to you as I am currently looking for participants for my Design Thinking Survey.

If you can take part please do the following:

Visit: www.lborodtresearch.co.uk (The site is best viewed in Chrome, Firefox, Internet Explorer 9, and Safari).

Click ‘Presentation’ tab to view the ‘What is Design Thinking’ presentation. The presentation was created from the findings of my literature review; it gives a brief overview of design thinking’s origins, history from the 1960s and application.

Click ‘DT Survey’ tab to complete the ‘Design Thinking Survey’ after viewing the presentation. The presentation is 16:30 minutes long with the audio. Should time be limited slide can be viewed at your own pace. The survey can take from 10 – 30 minutes long depend on the detail of your answers.
Thank you in anticipation of your participation in this research, I am extremely grateful for your contributions.

Then the participants completed the survey in their own time.

The survey was hosted on Survey Gizmo. The survey responses were collected between June–December 2013. The questions used in the online survey were the same as the interview questions; therefore, ensuring the data gathered to be consistent. Some questions were updated accordingly to avoid them being leading questions or double barrelled questions that could lead to a particular answer or confusion (Robson, 2011: 255).

Figures 37-39 are screenshots of the research website, the Design Thinking Survey and an example of a survey participant’s response. For the full Design Thinking Survey please refer to Appendix 12 and for the full survey response example please refer to Appendix 13.
Figure 37 Screenshot of the research website
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. If possible please give details of your previous experience of using design thinking:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Did the presentation reinforce your views on design thinking?</td>
<td>Yes, No</td>
<td></td>
</tr>
<tr>
<td>14. Did the presentation change your views on design thinking?</td>
<td>Yes, No</td>
<td></td>
</tr>
</tbody>
</table>
### 4. PART 1 Continued

9. Before viewing the presentation on this website have you heard of design thinking before?
   - Yes

10. What do you believe design thinking is?

Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem. It is a collaborative and multidisciplinary way of looking at, sketching, and proposing new systems and strategies in business, culture, political systems, health systems and the other organizing frameworks that affect our lives. It puts the user at the center of the design process and considers the many audiences, actors, and relationships in the design and redesign of systems.

11. Have you used or applied design thinking before?
   - Yes

### 5. PART 1 Continued

12. If possible please give details of your previous experience of using design thinking:

   I have used DT in the classroom to frame a collaboration process with students. I have also used DT in corporate settings with a design studio framing business problems and processes to create new cultural solutions inside the businesses.

### 6. PART 2

13. Did the presentation reinforce your views on design thinking?
   - Yes

14. Did the presentation change your views on design thinking?
   - No

### 7. PART 2 Continued

8. If yes, how did the presentation change your view and why?

### 8. PART 2 Continued

15. If yes, how did the presentation reinforce your view and why?

   It reinforced materials with which I was already familiar.
5.3. **Research ethics**

An approval from the Loughborough University Ethical Advisory Committee (EAC) was needed for research activity that required participants’ participations. This was achieved via the completion of the EAC check list (see Appendix 8). All participants’ took part in the study anonymously, this was to allow them to express their opinions freely and protect their privacy. Prior engaging in any research activities the participants were asked to read the research information sheet and filled in the informed consensus form (see Appendix 9). Furthermore, the participants had the right to withdraw from the studies any time if they want to. The research ethics approach taken was based upon one presented by Plowright (2011: 149-159) in *Using Mixed Methods*.

5.4. **Participants of the main study**

The final participant number was 56. 36 of them were from academia, within that 6 of them were interviews and 30 of them were online questionnaire responses. 20 practitioners took part in the research, 7 took part in interviews and the remaining 13 took the online survey. There is a rough 2:1 ratio between academic and practitioners. In addition to online recruitment, some of the participants were recruited during the d. Confestival Design Thinking Conference in September 2012 at Potsdam Hasso Plattner Institute School of Design Thinking.

The research employed theoretical sampling as discussed in Chapter 3.1.6. The participants were separated into two groups: academics and practitioners for data analysis purposes. Academics were identified under the following criteria:

- Must be working in an academic institution for a minimum of 24 hours a week in teaching or research positions.
- PhD students also counted as academics as they were conducting research in academia.
- Ideally have been working in academia for a minimum of 5 years.
Practitioners were identified under the following criteria:

- Must be working outside academia (e.g. design consultancy, engineering or professional services) for a minimum 24 hours a week.

- Ideally have a minimum of 5 years’ worth of experience in the field that they are working in.

Tables 23-28 give an overview of the participants’ job roles, area of expertise and location.
### 5.4.1. Academic participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-01</td>
<td>Part time PhD student</td>
<td>Ceramics (3 years)</td>
<td>Lisbon, Portugal</td>
<td>Survey</td>
</tr>
<tr>
<td>A-02</td>
<td>Senior lecturer</td>
<td>Graphic design, web design, computer animation, motion graphics and interface design (20 years)</td>
<td>Wellington, New Zealand</td>
<td>Survey</td>
</tr>
<tr>
<td>A-03</td>
<td>Professor of Design</td>
<td>Ergonomics, Product and system design, accident prevention, design innovation and experience design (35 years)</td>
<td>Auckland, New Zealand</td>
<td>Survey</td>
</tr>
<tr>
<td>A-04</td>
<td>Adjunct Professor of Public Health, principal of a design research firm</td>
<td>Service and innovation design and eHealth (12 years)</td>
<td>Toronto, Canada</td>
<td>Survey</td>
</tr>
<tr>
<td>A-05</td>
<td>Associate Dean of Graduate Studies</td>
<td>Interaction design and digital instruction (15 years)</td>
<td>Bloomington, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-06</td>
<td>PhD student, practicing graphic designer</td>
<td>Graphic design (14 years)</td>
<td>Abbotsford, Australia</td>
<td>Survey</td>
</tr>
<tr>
<td>A-07</td>
<td>PhD student</td>
<td>Industrial design (9 years)</td>
<td>Pittsburgh, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-08</td>
<td>Design academic</td>
<td>Industrial design (13 years)</td>
<td>Aveiro, Portugal</td>
<td>Survey</td>
</tr>
<tr>
<td>A-09</td>
<td>Part time design academic</td>
<td>Product design (39 years)</td>
<td>Ahmedabad, India</td>
<td>Survey</td>
</tr>
<tr>
<td>A-10</td>
<td>Associate Professor, PG studies in Art and Design</td>
<td>Publishing and practice led research (15 years)</td>
<td>Amsterdam, Holland</td>
<td>Survey</td>
</tr>
</tbody>
</table>

Table 23 Academic participants A1 - A10
<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-11</td>
<td>Department administrator, consultant</td>
<td>Media production (16 years)</td>
<td>Braunschweig, Germany</td>
<td>Survey</td>
</tr>
<tr>
<td>A-12</td>
<td>Professor of Design</td>
<td>Exhibition design (25 years)</td>
<td>Toronto, Canada</td>
<td>Survey</td>
</tr>
<tr>
<td>A-13</td>
<td>PhD student</td>
<td>Design (12 years)</td>
<td>Lancaster, UK</td>
<td>Survey</td>
</tr>
<tr>
<td>A-14</td>
<td>Business model design lecturer, part time consultant</td>
<td>Business and strategy (12 years)</td>
<td>San Marino</td>
<td>Survey</td>
</tr>
<tr>
<td>A-15</td>
<td>Furniture, interior and graphic design academic</td>
<td>Design (2 years)</td>
<td>Turkey</td>
<td>Survey</td>
</tr>
<tr>
<td>A-16</td>
<td>Professor in Design</td>
<td>Design research, mobility research and naval architecture (35 years)</td>
<td>Berlin, Germany</td>
<td>Survey</td>
</tr>
<tr>
<td>A-17</td>
<td>Independent design educator, former Dean of an architecture school</td>
<td>Architecture, industrial design and research (40 years)</td>
<td>Philadelphia, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-18</td>
<td>Design school librarian</td>
<td>Literature of design (22 years)</td>
<td>Pittsburgh, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-19</td>
<td>Architectural instructor</td>
<td>Architectural design (20 years)</td>
<td>State College, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-20</td>
<td>Design historian</td>
<td>Publication and product design (31 years)</td>
<td>Chicopee, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-21</td>
<td>PhD student</td>
<td>Graphic design and exhibition design (4 years)</td>
<td>Tokyo, Japan</td>
<td>Survey</td>
</tr>
<tr>
<td>A-22</td>
<td>PhD student</td>
<td>Graphics, communication and service design (20 years)</td>
<td>Sydney, Australia</td>
<td>Survey</td>
</tr>
</tbody>
</table>

Table 24 Academic participants A11 - A22
<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-23</td>
<td>Associate Professor in emergency medicine, biomedical engineering and industrial design</td>
<td>Medical device design (20 years)</td>
<td>Cincinnati, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-24</td>
<td>PhD student</td>
<td>Design, design management and design thinking (15 years)</td>
<td>Lancaster, UK</td>
<td>Survey</td>
</tr>
<tr>
<td>A-25</td>
<td>Associate Professor for interior design</td>
<td>Interior design (26 years)</td>
<td>Corvallis, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>A-26</td>
<td>Professor in design and media studies</td>
<td>Semiotic studies, insights and market studies (7 years)</td>
<td>Tunisia</td>
<td>Survey</td>
</tr>
<tr>
<td>A-27</td>
<td>Director of design studies and design PhD programmes</td>
<td>Sustainable design, service design and design philosophy (18 years)</td>
<td>Pittsburgh, USA</td>
<td>Interview</td>
</tr>
<tr>
<td>A-28</td>
<td>Head of research at an UK design school</td>
<td>Information design, visual representation theory and practice plus design research (20 years)</td>
<td>London, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>A-29</td>
<td>Lecturer</td>
<td>Cross domain design and design intent and user experience (11 years)</td>
<td>Cambridge, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>A-30</td>
<td>Assistant Professor of Design</td>
<td>Design education and design research (11 years)</td>
<td>Ulsan, Korea</td>
<td>Interview</td>
</tr>
<tr>
<td>A-31</td>
<td>Distinguished Professor of design</td>
<td>Design (40 years)</td>
<td>Melbourne, Australia</td>
<td>Survey</td>
</tr>
</tbody>
</table>

Table 25 Academic participants A23 - A31
<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-32</td>
<td>Emeritus Professor of Design</td>
<td>Architecture, design research, design methods, industrial design and social sciences in architecture (40 years)</td>
<td>Istanbul, Turkey</td>
<td>Survey</td>
</tr>
<tr>
<td>A-33</td>
<td>PhD student</td>
<td>Fashion design (30 years)</td>
<td>Derby, UK</td>
<td>Survey</td>
</tr>
<tr>
<td>A-34</td>
<td>Senior lecturer and creative director</td>
<td>Graphic design (15 years)</td>
<td>London, UK</td>
<td>Survey</td>
</tr>
<tr>
<td>A-35</td>
<td>Professor of design and director of two design research centres</td>
<td>Industrial design and design research (20 years)</td>
<td>Sydney, Australia</td>
<td>Interview</td>
</tr>
<tr>
<td>A-36</td>
<td>Design researcher</td>
<td>Design education and human centred design (7 years)</td>
<td>Stanford, USA</td>
<td>Interview</td>
</tr>
</tbody>
</table>

Table 26 Academic participants A32 - A36
### 5.4.2. Practitioner participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-01</td>
<td>Design studio owner and board member of a design PhD programme</td>
<td>Service design, interaction design and design strategy (17 years)</td>
<td>Linkoping, Sweden</td>
<td>Survey</td>
</tr>
<tr>
<td>P-02</td>
<td>Graphic and web designer and assistant editor of design journal</td>
<td>Graphic design (12 years)</td>
<td>Bloomington, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-03</td>
<td>NGO manager</td>
<td>Design management (15 years)</td>
<td>Istanbul, Turkey</td>
<td>Survey</td>
</tr>
<tr>
<td>P-04</td>
<td>Graphic design studio owner, part time design lecturer</td>
<td>Graphic design, typography, exhibition design and book design (13 years)</td>
<td>Phoenix, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-05</td>
<td>Sustainable design entrepreneur</td>
<td>Sustainable design (3 years)</td>
<td>Toronto, Canada</td>
<td>Survey</td>
</tr>
<tr>
<td>P-06</td>
<td>Account executive</td>
<td>Graphic design (15 years)</td>
<td>Cincinnati, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-07</td>
<td>Head of software engineering</td>
<td>Software products concept design and software architecture (30 years)</td>
<td>Montevideo, Uruguay</td>
<td>Survey</td>
</tr>
<tr>
<td>P-08</td>
<td>Start-up owner</td>
<td>Design and advertising (3 years)</td>
<td>Saint Paul, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-09</td>
<td>Consultant</td>
<td>Design innovation (25 years)</td>
<td>Badajoz, Spain</td>
<td>Survey</td>
</tr>
<tr>
<td>P-10</td>
<td>Design researcher</td>
<td>Information architecture, design and accessibility consulting (10 years)</td>
<td>Rio De Janeiro, Brazil</td>
<td>Survey</td>
</tr>
</tbody>
</table>

Table 27 Practitioner participants P1 - P10
<table>
<thead>
<tr>
<th>Participant</th>
<th>Role(s)</th>
<th>Area of Expertise (years)</th>
<th>Location</th>
<th>Interview or survey?</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-11</td>
<td>Co-founder of innovation consultancy</td>
<td>Innovation (30 years)</td>
<td>New York, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-12</td>
<td>Ex-board member of consumer electronics company</td>
<td>Interaction design, product design and management structure (33 years)</td>
<td>Palo Alto, USA</td>
<td>Survey</td>
</tr>
<tr>
<td>P-13</td>
<td>Art director and head researcher</td>
<td>Art and design led research (30 years)</td>
<td>San Juan, Puerto Rico</td>
<td>Survey</td>
</tr>
<tr>
<td>P-14</td>
<td>UK Head of service innovation agency</td>
<td>Product design, service design, design thinking and business design (20 years)</td>
<td>London, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>P-15</td>
<td>Managing director and lead designer at a UK product start-up</td>
<td>Product design and engineering (3 years)</td>
<td>London, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>P-16</td>
<td>Design studio owner and director</td>
<td>Transport design (35 years)</td>
<td>Leicester, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>P-17</td>
<td>Design studio founder and principal</td>
<td>Product design, graphic design and service design (5 years)</td>
<td>Haarlem, Holland</td>
<td>Interview</td>
</tr>
<tr>
<td>P-18</td>
<td>Design researcher and strategist</td>
<td>Design research and sustainability (5 years)</td>
<td>Warwick, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>P-19</td>
<td>Senior industrial designer</td>
<td>Industrial/ product design (7 years)</td>
<td>Warwick, UK</td>
<td>Interview</td>
</tr>
<tr>
<td>P-20</td>
<td>Senior industrial designer</td>
<td>Industrial/ product design (10 years)</td>
<td>Warwick, UK</td>
<td>Interview</td>
</tr>
</tbody>
</table>

Table 28 Practitioner participants P11 - P20
5.5. Data analysis

This section presents the data analysis methods used to develop the identify design thinking’s common characteristics and modes of expression, checking the reliability of data used to develop existing characteristics, identifying new common characteristics and how is design thinking expressed.

5.5.1. Thematic analysis

Thematic analysis was used for identifying evidence for existing and common characteristics as well as constructing the two consensus definitions of design thinking. It was used to analyse both data sets. Thematic analysis was the most suitable method for this as it was a flexible method that fitted into all types of qualitative data, the end result can provide a summary (in this case the evidence for the common characteristics and consensus) of key themes from a large amount of qualitative data and it was a quicker process when compared to others. (Robson, 2011: 477)

In order to identify evidence for the common characteristics and build the consensus definitions the researcher gathered all the definitions of
design thinking from the Design Thinking Survey and interview transcripts were gathered. Then they were separated into two groups: academics and practitioners. Figures 41 and 42 show the data coding examples. For the full thematic analysis coding sheets please refer to Appendix 14.
14th August 2013

Academics’ definitions of design thinking

Key:
- Descriptive Explanatory Evaluative Methodological
- Simple problems/Complex problems/ Social Challenges
- Problem solving/Problem creation
- Design thinking/creative thinking/Innovation/Invention

Addressing a problem using the "design" way of thinking.

- The application of creative processes systematically to addressing complex problems and generating possible alternatives and products.
- Ways of taking in, using and creating knowledge specific to designing in all its forms.

I find it very unclear, but would just summarise it as the problem-solution process used by many designers. I suspect it’s very similar (or possibly the same as) creative thinking or lateral thinking. It gave me some quotes I haven’t read before, and a few explanations and pieces of historical information I haven’t heard before that clarified some different points of view that exist (but also reinforced other things I already knew)

Design thinking is the application of design process and methods inside and outside topical contexts.

Design methodology

Design thinking should consider the design approach necessary for system design thinking.

Methodology for trans-disciplinary problem solving.

A trained approach to creative thinking.

A shared clear language. The first step of idea's creation.

An ill-defined hype term for a general method / strategy in essence what designers have always done.
14th August 2013

Practitioners’ definitions of design thinking

Key:
Design Process
Design thinking mindset and approach
Wicked problems
Problem solving
Outside Design
Creative/Creativity
Human centred
User centred
Multidisciplinary
Questions

The particular ways (in an extended cognition sense, that is both in the head and in the world) in which someone who is performing design thinking makes decisions, acts, articulates, remembers, directs attention, learns, communicates and reasons.

According to Nigel Cross (1982), there are four primary components of design thinking: it is constructive in nature, addresses "wicked" problems, is solution-focused, and works within a problem-solving orientation (but is not just problem solving).

Creative methods for business

A design-led mindset and approach to creative problem solving

Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem. It is a collaborative and multidisciplinary way of thinking, sketching, and proposing new systems and strategies in business, culture, politics, society, health systems and the other operating frameworks that affect our lives. It forms the core of the larger cycle of the design process and considers the many audiences, actors, and relationships in the design and redesign of systems.

Using truths from descriptive science and practice to abduct artefacts with high utility to one or more persons.

A good way of solving wicked problems, following a human centred process with frequent feedback from users. Also involving users on the design process.

Figure 42 Example page from thematic analysis of practitioners' definitions of design thinking
Once the data was separated into academics and practitioners sets, the first stage of thematic analysis took place. Here, the researcher familiarised himself with the data and identified the initial themes from the two groups (Robson, 2011: 476), as shown in Table 29:

<table>
<thead>
<tr>
<th>Initial themes from academics</th>
<th>Initial themes from practitioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving</td>
<td>Design processes/ design led/ design mindset</td>
</tr>
<tr>
<td>Complex problems/wicked problems/social challenges</td>
<td>Human centred/ User centred</td>
</tr>
<tr>
<td>Context (any)</td>
<td>Any context (Political, health, cultural)</td>
</tr>
<tr>
<td>Design/design process/design methodology</td>
<td>Problem solving</td>
</tr>
<tr>
<td>Experts/marketing professionals/multidisciplinary</td>
<td>‘Wicked’ problems</td>
</tr>
<tr>
<td>Outside typical context</td>
<td>Creative</td>
</tr>
<tr>
<td>Trans-disciplinary</td>
<td>Multidisciplinary</td>
</tr>
<tr>
<td>Divergent</td>
<td>Methods</td>
</tr>
<tr>
<td>Creative processes</td>
<td>Questions</td>
</tr>
<tr>
<td>Design knowledge</td>
<td>Bundle</td>
</tr>
<tr>
<td>Users</td>
<td></td>
</tr>
<tr>
<td>Human artefact</td>
<td></td>
</tr>
</tbody>
</table>

Table 29 Initial themes from academics and practitioners

Using these initial themes the process of constructing thematic networks took place and the initial themes were re-examined (Robson: 2011, 476). The relevant or similar initial themes were combined to form a key theme. Using the common characteristics identified from the literature review and pilot studies as guidance the key themes were constructed. The process was repeated until all themes were either combined into key themes or deleted as they were irrelevant. Once the constructing thematic network process was done there were 16 key themes left, eight for academics and eight for practitioners as shown in Table 30:

---

2 The themes are presented in the order they were in on the handwritten script.
### Key themes from academics | Key themes from practitioners
---|---
Creative thinking/ creativity | Creative/ creativity
Complex problems/ wicked problems/ social challenges | Design processes/ design led mind set and approaches
Design/ design process/ design methodology | Human centred/ user centred
Divergent | Multidisciplinary
Experts/ multidisciplinary | Outside design (Business, culture, health political)
Problem context/ outside design | Problem solving
Problem solving | Questions
Users | Wicked problem

Table 30 Key themes of design thinking from academics and practitioners

The key themes will be discussed in detail in the next section of this Chapter. After having identified the key themes, the final step of data analysis was integration and interpretation (Robson: 2011, 476). Here, the key themes that matched identified common characteristics were coded together as the first step of building evidence to support them. Those that were not matched were analysed to see if they could become new common characteristics themselves. In addition to begin building the evidence for the common characteristics, the findings from the thematic analysis were also used to develop the consensus definition of design thinking that will be discussed in Chapter 6.

#### 5.5.2. Thematic analysis findings

As shown in Table 30, 16 key themes were identified from the thematic analysis process. The data appeared to show key themes matching the common characteristics identified from the literature review and pilot studies, new common characteristics were also identified from the data. This section discloses those findings. The data used to construct the key themes was visualised using word clouds. The word clouds were created from Nvivo 10. Word cloud was selected as the method to visualise the data because it is an easily understandable way to represent word frequency in the data, the bigger the word the more frequent it appeared.
The findings are presented in two sections (academics and practitioners); Table 31 shows how the key themes matched under existing and newly identified common characteristics:

<table>
<thead>
<tr>
<th>Common characteristics identified from literature and pilot studies</th>
<th>Matching academics’ key themes</th>
<th>Matching practitioners’ key themes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drivers</strong></td>
<td>Users</td>
<td>Questions</td>
</tr>
<tr>
<td><strong>Experts</strong></td>
<td>Experts/ multidisciplinary</td>
<td></td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>Problem solving</td>
<td>Creative/ creativity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem solving</td>
</tr>
<tr>
<td></td>
<td>Divergent</td>
<td>Human centred/ user centred</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multidisciplinary</td>
</tr>
<tr>
<td><strong>Processes (CC)</strong></td>
<td>Design/ design process/ design methodology</td>
<td>Design processes/ design led mind set and approaches</td>
</tr>
<tr>
<td></td>
<td>Creative thinking/ creativity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problem solving</td>
<td></td>
</tr>
<tr>
<td>‘Design problems’, traditional or non-traditional</td>
<td>Complex problems/ wicked problems/ social challenges</td>
<td>Outside design (Business, culture, health, political)</td>
</tr>
<tr>
<td></td>
<td>Problem context/ outside design</td>
<td>Wicked problem</td>
</tr>
<tr>
<td><strong>New common characteristics identified from thematic analysis</strong></td>
<td>Matching academics’ key themes</td>
<td>Matching practitioners’ key themes</td>
</tr>
<tr>
<td><strong>Multidisciplinary</strong></td>
<td>Experts/ multidisciplinary</td>
<td>Multidisciplinary</td>
</tr>
<tr>
<td><strong>Knowledge</strong></td>
<td>Users</td>
<td>Questions</td>
</tr>
</tbody>
</table>

Table 31: Matching the common characteristics identified with the academics and practitioners’ key themes
5.5.2.1. Academics’ key themes

Design/ design process/ design methodology

![Academic word cloud of the key theme 'design/ design processes/ design methodology'](image)

Figure 43 shows the academic word cloud of the key theme. It was the most common key theme from the academics data set. In terms of coverage within the data, 16% of the words from the set were coded under it. The words coded under the key theme suggested it was a match with the common characteristic processes (CC). From the data it appeared academics believed the key theme was an important part of design thinking because without these design processes or methodology design thinking would not take place. These were some of the examples provided by the academics that led to the analysis above:

‘Addressing a problem using the "design" way of thinking.’ (Academic A2, survey, June 2013)

‘in design and development of industrial products’ (Academic A8, survey, June 2013)

‘You might have the engineering orientated designer and many different kinds of things we are designing if we take the term industrial design, and the engineering orientated designer is designing the Dreamliner as oppose to Stark designing a new lemon squeezer.’ (Academic A30, interview, August 2013)
Figure 44 shows the academic word cloud of the key theme ‘problem context/ outside design’ within the academics data set. From the data it appeared that the key theme was a match for the common characteristic: ‘design problems,’ traditional or non-traditional. The data suggested that academics saw design thinking could be applied in other contexts; therefore, it can be used to solve traditional or non-traditional design problems. These were some of the examples provided by the academics that led to the analysis above:

‘If you want a textbook answer the traditional design problem is the ill-defined design problem that requires a solution focus approach to understanding the design problem.’ (Academic A30, interview, August 2013)

‘Things I talked about sort redesigning a whole East side of Holland. It is beyond any specific design discipline. It is also on a different scale, it goes beyond I am a product designer and work for a manufacturer and I am give in my drawings at the end of my project and it will be made. It put you into a completely different position relative to realisation.’ (Academic A35, interview, August 2013)
**Problem solving**

Figure 45 The academic word cloud of the key theme ‘problem solving’

Figure 45 shows the academic word cloud of the key theme. Problem solving was another theme emerged from the academics data set. The data suggested that academics saw design thinking was a problem solving process; as a result, problem solving could also be seen as an impact of design thinking. Despite problem solving being an impact of design thinking academics did not emphasised on that aspect heavily. From the data it appeared problem solving was a match for the following common characteristics: processes (CC) and impact. These were some of the examples provided by the academics that led to the analysis above:

- ‘methodology for transdisciplinary problem solving’ (Academic A11, survey, June 2013)

- ‘In practice, I use design thinking almost every day to solve problems for organisations.’ (Academic A21, survey, August 2013)

- ‘A non-traditional design program incorporates the interaction of other disciplines working collaboratively to solve a problem.’ (Academic A23, survey, August 2013)

**Complex problems/ wicked problems/ social challenges**

Figure 46 The academic word cloud of the key theme ‘complex problems/ wicked problems/ social challenge’
Figure 46 shows the academic word cloud of the key theme. Words coded under complex problems/wicked problems/social challenges were used by the academics to describe the problems that design thinking solved; therefore, it was matched with the common characteristic: ‘design problems’, traditional or non-traditional as suggested by the data. These were some of the examples provided by the academics that led to the analysis above:

‘The application of creative processes systematically to addressing complex problems and generating possible alternatives and products.’ (Academic A4, survey, June 2013)

‘The design problem is ill defined yea... The one thing you can say about the design problem is that always...’ (Academic A30, interview, August 2013)

**Users**

Figure 47 shows the academic word cloud of the key theme 'users'. From the academics’ viewpoint users were seen as a resource when employing design thinking. Here, it meant users involvement when employing design thinking was expected by the academics; furthermore, users sometimes were also seen as drivers that kick started projects. From the data it appeared users were a match for the common characteristic: drivers. In addition, the data from users also led to the identification of a new common characteristic: knowledge. Knowledge was identified from the key theme though users involvement and interaction stated by academics when they were giving their views on what design thinking was. This was
one of the examples provided by the academics that led to the analysis above:

‘Whereas now there is a much stronger awareness that the object exists in a context of use, users, production, ecology, economy and so far.’ (Academic A28, interview, July 2013)

**Creativity or creative thinking**

![Figure 48 The Academic word cloud of the key theme 'creativity or creative thinking'](image)

Figure 48 shows the academic word cloud of the key theme. From the academics' viewpoint, creativity or creative thinking was as a requirement that was needed to sufficiently employ design thinking. The words coded under the key theme suggested it was a match with the common characteristic: processes (CC). These were some of the examples provided by the academics that led to the analysis above:

‘A creative process in human-artefact-environment analysis, design, and evaluation of product, service and/or brand design to ensure successful innovation/entrepreneurship.’ (Academic A3, survey, June 2013)

**Experts/ multidisciplinary**

![Figure 49 The Academic word cloud of the key theme 'experts/ multidisciplinary'](image)

Figure 49 shows the academic word cloud of the key theme. Despite looking similar to the practitioners’ key theme multidisciplinary; the
academics’ key theme was very different. From the academics’ viewpoint, employing the suitable experts was vital, as the participation of suitable experts were directly link to creating suitable solutions to the problem given when solving it with design thinking. Therefore, from the academic viewpoint without the suitable experts, it was not possible to use design thinking to its full potential. The data also demonstrated that the academics’ viewpoint believed the suitable experts (regardless of their discipline) were required to create suitable solutions; the relevant experts from different fields would need to take part and be included as part of the process. From the data, the key theme appeared to be a match with the common characteristics: experts and knowledge. A new common characteristic was also identified from the data under the key theme; it was multidisciplinary. This was one of the examples provided by the academics that led to the analysis above:

‘process of iterative checking/experimentation of components of a designed object/experience, working with relevant experts and users to refine all into an new useful, usable, enjoyable and elegant product/experience’ (Academic A18, survey, June 2013)

Divergent

Figure 50 The Academic word cloud of key theme ‘divergent’

Figure 50 shows the word cloud of the key theme. Divergent was a unique key theme identified from the academics data set. From the contexts in which it emerged from, the data suggested academics saw divergent being an impact of employing design thinking. Some academic viewpoints believed using design thinking can created divergent solutions from other disciplines. Therefore, as the data suggested it was a match for the
common characteristic: *impact*. These were some of the examples provided by the academics that led to the analysis above:

‘A way of thinking that is empathetic, divergent and convergent, reiterative and flexible within constraints.’ (Academic A22, survey, July 2013)

‘Divergent thinking’ (Academic A33, survey, August 2013)

**5.5.2.2. Practitioners’ key themes**

*Design processes/ design led mind set and approaches*

![Word Cloud](image)

Figure 51 The practitioner word cloud of the key theme ‘design processes/ design led mind set and approaches’

Figure 51 shows the word cloud of the key theme. From the practitioners’ data set, design processes/ design led mind set and approaches had the most words coded under it, making it the most common key theme within the data. From the data it appeared that practitioners saw the key theme being the requirement for design thinking application. From the contexts in which the words coded under it came from, the key theme appeared to be a matched for the common characteristic: *processes* (CC). These were some of the examples provided by the practitioners that led to the analysis above:

‘It puts the user at the center of the design process and considers the many audiences, actors, and relationships in the design and redesign of systems.’ (Practitioner P4, survey, June 2013)
‘A good way of solving wicked problems following a human centred process with frequent feedback from users. Also involving users on the design process.’ (Practitioner P7, survey, June 2013)

**Problem solving**

Figure 52 The practitioner word cloud of key theme 'problem solving'

Figure 52 shows the word cloud of the key theme. From the practitioners’ data set, problem solving was seen as a major impact of using design thinking. Therefore, from the viewpoints put forward it appeared to be a match to the common characteristic *impact*. These were some of the examples provided by the practitioners that led to the analysis above:

‘A creative process in which the ultimate goal is to resolve a problem.’ (Practitioner P6, survey, June 2013)

‘It is a non-usual way of solve problems used by designers.’  (Practitioner P10, survey, June 2013)

**Outside design (Business, culture, health, political)**

Figure 53 The practitioner word cloud of the key theme 'outside design (business, culture, health, political)’
Figure 53 shows the word cloud of the key theme. From the practitioners’ data set, the key theme appeared to describe the contexts in which design thinking could be applied in. The data suggested it appeared to be a match for the common characteristic: ‘design problems’, traditional or non-traditional. These were some of the examples provided by the practitioners that led to the analysis above:

‘Practitioners, IDEO is a good example they talk about design thinking, in reality most practitioners are still product centred or design led, what they use design thinking for is to approach design within business in a strategic level.’ (Practitioner P14, interview, June 2013)

‘Obviously when I taught it was in the early 70s so I think so of the basic are the same but some we weren’t taught anything if you like business context or sponsor context we weren’t taught anything about brand.’ (Practitioner P16, interview, June 2013)

Wicked problem

Figure 54 shows the word cloud of the key theme ‘wicked problem’. From the practitioners data set, the key theme wicked problem was used to described the problems solved by design thinking. Therefore, according to the data it was a match for the common characteristic: ‘design problems’, traditional or non-traditional. These were some of the examples provided by the practitioners that led to the analysis above:
‘A wicked problem in which the designer has to understand the problem while exploring the solution’ (Practitioner P7, survey, June 2013)

‘Wicked problems.’ (Practitioner P13, survey, June 2013)

*Creative/ creativity*

![Word Cloud](image)

Figure 55 The practitioner word cloud of the key theme ‘creative/ creativity’

Figure 55 shows the word cloud of the key theme. Despite being similar to the academics’ key theme, creative thinking/ creative; the practitioners’ key theme was very different. From the practitioners data sets it appeared creative/ creativity was seen as an impact of employing design thinking rather than a requirement. As a result of the data, the practitioner key theme appeared to be a match for the common characteristic: *impact*. These were some of the examples provided by the practitioners that led to the analysis above:

‘I think the definition for me is the creative process of design within additional contexts such as business strategy or organisation strategy, commercial business and particularly branding. When I was at college there was no branding existing.’ (Practitioner P16, interview, June 2013)

‘A lot of people use design thinking for creativity and innovation and thinking outside the box.’ (Practitioner P19, interview, December 2013)
**Human centred/ user centred**

Figure 56 The practitioner word cloud of the key theme 'human centred/ user centred'

Figure 56 shows the word cloud of the key theme. From the practitioners’ data set, human centred/ user centred was the second most common key theme. Compare to its counterpart in the academics’ data set it had a lot more words coded under it. Despite looking similar to its academics’ counterpart, the practitioners’ data set suggest it had a different meaning. From the practitioners’ viewpoint, human centred/ user centred was seen as an impact of employing design thinking. The practitioners’ data suggested employing design thinking enable organisations or companies to engage with its users. From that viewpoint, it appeared to be a match with the common characteristic: *impact*. These were some of the examples provided by the practitioners that led to the analysis above:

‘Design Thinking is an ever evolving bundle of approaches focused on creating a more human centered, life centered world.’ (Practitioner P11, survey, June 2013)

‘And I think design thinking is much more about... first it is human centred rather than data centred it tends to be the approach of many business people and manager use for problem solving.’(Practitioner P14, interview, June 2013)

**Multidisciplinary**

Figure 57 The practitioner word cloud of the key theme 'multidisciplinary'
Figure 57 shows the word cloud of the key theme. Despite looking similar to its academics’ counterpart; the practitioners’ key theme multidisciplinary had a different meaning. From the practitioners data set, multidisciplinary appeared to be seen as an impact of using design thinking. From the practitioners’ viewpoints design thinking was a process that could be used by anyone to solve any problem given. In addition, the data also suggested the practitioners’ viewpoints believed design thinking to be a multidisciplinary process. As a result of those viewpoints, the key theme appeared to match the following common characteristics: impact and multidisciplinary. Below is an example provided by the practitioners that led to the analysis above:

‘We used a transdisciplinary approach. We used a local mind-set with our own methodologies that are better adapted to peripheral design practices’ (Practitioner P13, interview, June 2013)

**Question**

Figure 58 shows the word cloud of the key theme ‘question’. Question was a unique key theme from the practitioners’ data set. The data suggested that asking questions was a way of framing the problem. Asking questions appeared to be a way for practitioners to identify the drivers behind the problems and the knowledge needed to understand and reframe them. From the data, the key theme appeared to be a match with the following common characteristics: drivers and knowledge. Below were some of the examples provided by the practitioners that led to the analysis above:

‘It's how I live my life: Ask the right question – one that is both important and answerable. Get to the fundamentals, the root cause.’ (Practitioner P12, survey, June 2013)
‘It uses design led approaches, it’s human centred, it focuses on not finding the right solution by first finding the right question.’ (Practitioner P14, interview, June 2013)

5.5.3. Content analysis

Content analysis was the second method employed to analyse the data sets. The goal of the content analysis was to identify evidence supporting the common characteristics identified from the literature review, pilot studies and thematic analysis. In addition the process was also used to check the reliability of the findings so far. Content analysis comprised of three stages as presented in Figure 59: the research problem being stated and identified, retrieving data via sampling method chosen and finally interpretation and conducting analysis (May, 2001: 191-192). In the case of this thesis the research problems were identified at the beginning, data was collected via the research instrument and the data collected was analysed by thematic analysis and content analysis. Both thematic and content analyses were conducted on Nvivo 10 software. Nvivo was used because all data can be easily managed and gathered in one place. Furthermore the software allows different visual output of the
data such as word clouds and relationship maps. There were three stages of coding in the content analysis process. The first stage was open coding; here the data was split into discrete parts, in the case of this thesis the data was split according to the seven common characteristics identified from the literature review, pilot studies and thematic analysis. The common characteristics were:

- Drivers
- Experts
- Impact
- Processes
- ‘Design problems’, traditional or non-traditional
- Multidisciplinary
- Knowledge

Once all the data belonged to the seven common characteristics were coded and grouped into the suitable places, the remaining data then went through open coding again to see if any new common characteristics could be established.

The next section of this chapter will present and discuss the evidence that support these common characteristics in detail. Once the open coding phase was completed the analysis moved on to the axial coding phase. Here all the data that were coded into the seven common characteristics were then sorted again to create the sub-categories within the evidence. This allowed the qualitative data driven design thinking model to take shape. The axial coding process also allowed the researcher to double check the coded and un-coded data to ensure all data were put into the suitable common characteristics. The axial coding process also provided the opportunity to create an overview of the relationship between the coded data. The final stage of content analysis was selective coding. Here all data coded as common characteristics supporting evidence were re-
examined to identify design thinking’s mode of expressions. The purpose of the selective coding process was to provide further analysis on selected core categories of design thinking’s modes of expression. Please refer to Appendix 15a for the coding diagrams. For this analysis, five categories were selected based upon academics and practitioners literature and a doctoral thesis (Ambrose and Harris, 2010; Baynes, 2013; Berger, 2009; Cross, 2011; Danos, 2011; DPRG, 2014; Paterson, 2013), the five categories used for identifying design thinking’s mode of expressions were graphicacy, language, numeracy, physical and processes. These categories will be discussed in detail in a later section in the Chapter alongside the modes of expression analysis findings. The findings of the content analysis and thematic analysis were used to develop the qualitative data driven model of design thinking.

5.5.4. Content analysis findings

Seven common characteristics of design thinking were identified from literature review, thematic analysis and content analysis. This section of the Chapter presents these common characteristics and their supporting evidence from the data in detail.

5.5.4.1. Drivers

Drivers was one of the first common characteristics identified and it was identified from the literature review. From the findings of the literature review, this common characteristic had the following meaning: drivers were the external factors that kick started any project. Drivers kick started a project by either stimulating the identification of a problem or an opportunity. In the context researched, an example of a problem from the literature review would be the need for a better way to detect hostile intent and objects at airport security checkpoints (Brown, 2009: 184-188). In the context researched, an example of an opportunity would be identifying an alternative application with existing technologies; such as the motion sensors used in the Nintendo Wii console’s controllers. This example was identified from the literature review (Veganti, 2009: 60–67). The meaning of the common characteristic was then used in the axial
Coding phase of content analysis to identify the common characteristic’s supporting evidence from the data sets. From the data sets the following words were coded under *drivers* and their frequency within the data is displayed in the Tables 32-33:

<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
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<td></td>
<td></td>
<td>OS A17, P1</td>
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<td>1</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>OS A6</td>
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</tr>
<tr>
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<td>IN</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P14</td>
<td></td>
</tr>
<tr>
<td>Culture</td>
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<td>9</td>
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<tr>
<td></td>
<td></td>
<td>OS A10, A26, A33, P4</td>
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<td>2</td>
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<td>human centred</td>
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<td>OS P14</td>
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<td></td>
<td></td>
<td>OS A21</td>
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<td>1</td>
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<td></td>
<td></td>
<td>OS A27</td>
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</tr>
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<td></td>
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</table>

Table 32 Words coded under the common characteristic drivers during content analysis

\(^3\) IN: Interviews; OS: Online Survey    A: Academic; P: Practitioner
Table 33 Words coded under the common characteristic drivers during content analysis

(Continued from Table 32)

<table>
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<th>Words</th>
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<th>Frequency</th>
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<td></td>
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Figure 60 The common characteristic 'drivers' and its supporting evidence

\(^4\) IN: Interviews; OS: Online Survey  A: Academic; P: Practitioner
Figure 60 shows the evidence coded under the common characteristic *drivers* from axial coding and presents the links between them. From the data, six of the nodes had no sub-categories coded under them; those were: business goals, Design Methods Movement, questions, the root cause, user experience and users’ point of view. Therefore, they formed part of the evidence but did not become a supporting theme. As shown in Figure 60, the following became supporting themes as a result of having additional nodes coded under them:

- Constraints
- Culture
- External factors

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.

**Constraints**

*Constraints* was the first supporting theme being identified from the data and the following nodes were coded under: *budget, objective and resources*. Those were coded under *constraints* under the contexts from which they emerged.

**Culture**

*Culture* was the next supporting theme that emerged from the data. The following words were coded under the supporting theme: *corporate values, data centred, design for sustainability, human centred, organisation centred and sustainable lifestyle*.

*Data centred and human centred*:

The next sets of words that were coded under culture was *data centred and human centred*. Both were identified from a practitioner interview. The interviewee explained the meaning of data centred and human centred by using the following example:
‘(...) And I think design thinking is much more about... first it is human centred rather than data centred it tends to be the approach of many business people and manager use for problem solving.’ (Practitioner P14, interview, June 2013)

From the words used by the interviewee it appeared that the interviewee was describing the current operation culture within businesses. Therefore, they were coded under culture.

Design for sustainability and sustainable lifestyle:

*Design for sustainability and sustainable lifestyle* were identified from an interview with an academic (A27). They were coded under culture because of the contexts in which they were presented by the interviewee:

‘So a quick example is that in NYC I was involved in a DESS project so it is a network of researchers concern about design for sustainability and social innovation this particular methodology is that designers don't come up with the good ideas they find good ideas hidden in the community, the community has people already innovating sustainable lifestyle.’ (Academic A27, interview, July 2013)

From the context in which both phrases emerged from it appeared that the interviewee was describing the cultural change that the project he took part in was trying to embrace from the *design for sustainability* viewpoint.

Organisation centred:

The words emerged from an academic survey response (A21) when the participant was giving her views regarding design thinking:

‘I agree with Lucy Kimbell (2011) that design thinking should move from being designer-centred or organization-centred to a more practice-theory based approach that views design as a social process.’

(Academic A21, survey, August 2013)

From the response given, it could be said that *organisation centred* belonged to culture as she was expressing design can be seen as a social process.
**External factors**

*External factors* was the final supporting theme identified from the data that was backed up by a number of different words as evidence. The words that were coded into the supporting theme were: *market, political and technology*. Examples could be identified from the data for *market* and *political*.

**Market:**

*Market* emerged from academics and practitioners’ interviews and survey responses. A few examples were given regarding what *market* meant from their point of view, all the data was similar describing *market* being the place where they intend to sell a product and it was also a factor that could shape the objectives and outcome of a project. In addition, the responses also gave examples from the social innovation viewpoint where market was not a dominating factor.

**Political:**

From the response given *political* appeared to be an external factor as policies could easily affect the objectives and outcome of a design project. An example of politics being a major factor for a design project would be the TSA Security Checkpoint Evolution by IDEO that was presented in chapter 2.4.6 (page 82–85). The nature of that project justified coding political under external factors.

**5.5.4.2. Experts**

*Experts* was the next common characteristic identified from the literature review. From the findings of the literature review this common characteristic had the following meaning: experts were the people from different disciplines who were involved with the project because their expertise was required to help generate suitable solutions to the problem. In the context researched, the following examples were identified as experts from a design project presented in the literature review (Brown, 2009: 185–188 & IDEO, 2013): product and service designers, Transportation Security Administration (TSA) security agents, airlines staff
at terminals and passengers. In addition to being examples of experts, this is also an example of possible constituents for a multidisciplinary team. In the same way as the previous common characteristic the meaning of experts was used in the axial coding phase of content analysis to identify the supporting evidence from the data set. From the data sets the following words were coded under experts and their frequency within the data is presented in Tables 34-35:

<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experts</td>
<td>8</td>
<td>IN&lt;sup&gt;5&lt;/sup&gt; A30, A35, A36, P15 OS A6, A8, A18, P2</td>
<td>18</td>
</tr>
<tr>
<td>Academia, academic</td>
<td>17</td>
<td>IN A27, A29, A30, A36, P14, P16, P17, P18, P19, P20 OS A7, A16, A17, A21, P1, P4, P5, P12, P13</td>
<td>32</td>
</tr>
<tr>
<td>Business school</td>
<td>3</td>
<td>IN A27, A35, P14 OS</td>
<td>17</td>
</tr>
<tr>
<td>Design school</td>
<td>5</td>
<td>IN A27, A29, A30, A35, P14 OS</td>
<td>13</td>
</tr>
<tr>
<td>DTRS (Design Thinking Research Symposium)</td>
<td>1</td>
<td>IN A27 OS</td>
<td>6</td>
</tr>
<tr>
<td>Expert teachers</td>
<td>1</td>
<td>IN A36 OS</td>
<td>1</td>
</tr>
<tr>
<td>Architects</td>
<td>1</td>
<td>IN P15 OS</td>
<td>4</td>
</tr>
<tr>
<td>Child expert</td>
<td>1</td>
<td>IN A36 OS</td>
<td>1</td>
</tr>
<tr>
<td>Craftsman</td>
<td>1</td>
<td>IN A30 OS</td>
<td>1</td>
</tr>
<tr>
<td>Creative professional</td>
<td>1</td>
<td>IN OS P2</td>
<td>1</td>
</tr>
<tr>
<td>Design Council</td>
<td>1</td>
<td>IN P15 OS</td>
<td>1</td>
</tr>
<tr>
<td>Design thinkers</td>
<td>5</td>
<td>IN A29, A35, A36, P14 OS A21</td>
<td>6</td>
</tr>
<tr>
<td>Design thinking company</td>
<td>1</td>
<td>IN A30 OS</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 34 Words coded under the common characteristic experts during content analysis

<sup>5</sup> IN: Interviews; OS: Online Survey  A: Academic; P: Practitioner
<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OS: A6, A7, A16, A19, A21, P2, P5, P7, P10, P12</td>
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</tr>
<tr>
<td>Design company</td>
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<td>18</td>
</tr>
<tr>
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<td>OS: A21, A24, P1</td>
<td></td>
</tr>
<tr>
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<td>1</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Design researcher</td>
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<td>IN: A30, A35, P18</td>
<td>7</td>
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<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Interaction designers</td>
<td>2</td>
<td>IN: A27, A30</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Service design agencies</td>
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<td>IN: A27</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Service designers</td>
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<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
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<td>IN: A36</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
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<td>IN: A27, A28, A30</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS: A11, A23, P4, P13</td>
<td></td>
</tr>
<tr>
<td>Non-designers</td>
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<td>IN: A28, A29, A30, A35, A36</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS: A21</td>
<td></td>
</tr>
<tr>
<td>Management and strategic consultant</td>
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<td>IN: A27, A29</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Board room</td>
<td>3</td>
<td>IN: P14, P18, P19</td>
<td>3</td>
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<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Managers</td>
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<td></td>
<td>OS: A9</td>
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</tr>
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<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>OS: A23</td>
<td></td>
</tr>
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<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS:</td>
<td></td>
</tr>
<tr>
<td>Social service agencies</td>
<td>1</td>
<td>IN:</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS: A4</td>
<td></td>
</tr>
</tbody>
</table>

Table 35 Words coded under the common characteristic experts during content analysis (Continued from Table 35)

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6 IN: Interviews; OS: Online Survey   A: Academic; P: Practitioner
Figure 61 shows the data coded under experts during axial coding and presents the links between them. From the data, three of the nodes had no sub-categories coded under them; those were: creative professionals, guru and social service agencies. Therefore, they formed part of the evidence but did not become a supporting theme. As shown in Figure 61, the following became supporting themes as a result of having additional nodes coded under them:

- Academia/ academic
- Design thinkers
• Designer

• Multidisciplinary

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.

**Academia/academic**

Academic/academic was the first supporting theme identified form the data. The following words were coded under the theme: *business schools, design schools, DTRS (Design Thinking Research Symposium) and expert teachers.*

**Business School:**

The participants believed *business school* being an interested party of using design thinking. They provided the following examples:

‘(...) the guy who is in charge of the business school there embraced design thinking heavily and he was talking a lot to Stanford and thinking that as dean of UTS Business School he was going to bring design thinking to the business school.’ (Academic A27, interview, July 2013)

‘Yes, because I think most academics are just getting into it as a term if you like and most of the academics are in design schools they are not in business school and it is quite interesting as in business schools they are still talking about innovation and creativity. They don’t talk about design thinking and they don’t talk about design at all.’ (Practitioner P14, interview, June 2013)

From the examples given it appeared that business schools were interested in either using or teaching design thinking. Therefore, it was coded under the supporting theme.

**Design School:**

The participants believed that *design schools* were places where design was being taught. However, the data suggested that *design schools*
seemed to see design thinking differently to business schools. Despite
the viewpoint of design schools having a different vision of what design
thinking could be, all agreed that design schools were environments
where design thinking occurred. As a result of those responses and the
contexts that they emerged from, it was coded under the supporting
theme.

DTRS (Design Thinking Research Symposium):

DTRS was coded under the supporting theme because of its origins:

‘The series of symposia was initiated by Nigel Cross with Norbert
Roozenburg and Kees Dorst at Delft University of Technology, The
Netherlands, in 1991, with what was initially expected to be a one-off
international meeting on ‘Research in Design Thinking’. But the
content and format of that meeting were felt by the participants to be
so good as to warrant more of the same. (...) The series of meetings
has produced a substantial set of publications in books and journals,
with significant research results, and has helped to foster an
international community of scholars and researchers focused on
design cognition.’ (Cross, 2012)

As the description given by Cross suggests the DTRS was formed to
encourage researcher and academics to engage and focus on research
related to design thinking, therefore, it was coded under academia/
academics.

Expert teachers:

Expert teachers emerged from an academic interview. The interviewee
used the phrase to describe the people that were involved with an
education project that he organised when asked about examples of
design thinking application.

Design thinkers

The data suggested from the academic perspective design thinker was
seen as a way to describe experts in applying design thinking in that case
the example given from an academic survey response described it as a way those outside design described designers. However, from the practitioner’s viewpoint a design thinker could be someone who thinks differently to solve a problem, the following example was given:

‘He was talking to me about design thinking a year ago on the basis that he can see design thinkers as being heretics. Heretics can be design thinkers that can get people to think differently.’ (Practitioner P14, interview, June 2013)

*Design thinking company:*

*Design thinking company* was the only term coded under *design thinker*. It emerged from an academic interview when the interviewee was asked about additional example of companies who employed design thinking. The interviewee used IDEO as an example of a *design thinking company* that was widely recognised in terms of its application and contemporary understanding of design thinking. The example given by the interviewee provided the evidence to code it under *design thinkers*.

*Designers*

*Designers* was a supporting theme that emerged from academic and practitioner interviews and survey responses The following words were coded under the supporting theme: *design company*, *design engineer*, *design researcher*, *interaction designer*, *service designers* and *service design agencies*.

*Design company:*

It was used by the participants to describe the environment in which design thinking was being applied commercially. Here is an example from the data:

‘There is also a main difference; in academia one is more interested in understanding and addressing thinking, whereas the main interest in commercial life is to apply/use design thinking to achieve business goals. That is, in academia who is capable of design thinking is not
important in itself, but it may be for a design company.’ (Practitioner P1, survey, June 2013)

Above was an example showing the contexts that design company emerged from. As a result of the context it was identified from, it was coded under designers.

**Design engineer:**

It was coded under the supporting theme because the interviewee used it to describe the different types of experts required to tackle design thinking problems.

**Design researcher:**

The term was used by the interviewees to describe a very specific role within the field of design and the type of research that were conducted. The interviewees gave the following examples as the specific research activities conducted by design researchers: identifying emerging methodologies from design academia and conducting their development and application in a commercial environment; understanding and getting to grips with what designers do. The examples gave a clear description of the role of design researcher within the design field; therefore, it was coded under the supporting theme.

**Interaction designer:**

Examples of what an interaction designer were given by the interviewees. The examples suggested all designers were interaction designers to a certain degree and this was caused by designers’ ability to ‘fuse people with things and see things better than others’ (Interview with A27). Using that viewpoint, designer was the support theme that was most suitable to code the term under.

**Service design agencies and service designers:**

The participant gave an overview of the latest developments in the service design sector in the UK and US. The example also listed the differences between the UK and US:
‘There have been two or three attempts to create service design agencies however they have all been folded or brought by regular agencies. The service design community remains marginal and small. The service design space that is growing in the US and perhaps not growing in the UK that I know is thinking about digital services overlapping provider, platform, thinking of your iPhone as a service system which you have a whole series of co-operating, competing players and a whole series of user intentions. App as a software service is very big in the US at the moment. The whole service community here in the US has moved into that kind of tech design space.’ (Academic A27, interview, July 2013)

From the example provided, it appeared that the two terms should be coded under designers as it was describing a specific sector of the design industry.

**Multidisciplinary**

*Multidisciplinary* was a support theme that emerged from the data. With the academic and practice literature evidence suggests design thinking being a multidisciplinary process; the identification of the supporting theme checked the reliability of the data emerged from the literature review.

*Non-designers:*

Most of the data within the supporting theme was coded under *non-designers*. It emerged from the data gathered from academic interviews and survey responses. *Non designers* was a term used by academics to describe those outside the design sector who claimed to apply design thinking in their practices or interested in applying it:

‘I guess I am surprised to see for me a relatively, relative to my own assumptions there seems to be not so much about non designers using design thinking in cooperate settings, the movement of design up the cooperate agenda into the boardroom. I can see you have
Nussbaum there; I am looking at the transcript there.’ (Academic A29, interview, July 2013)

The example given suggested that non-designers was to be coded under the supporting theme of multidisciplinary.

The following words were coded under non-designers: engineers, management and strategic consultants, board room, managers, strategic consultants, marketing professionals and software engineers.

**Engineers:**

*Engineers* emerged when the interviewee was giving a description of the relationship between designers and engineers:

‘Some of them do, I think structure engineers should be more the same type of thing because, that is why product designers are better we are closer to engineers. Engineers will laugh but we have a certain and better degree of understanding to engineering.’ (Practitioner P15, interview, June 2013)

From the context in which it emerged from, it was logical to code it under non-designers.

**Management and strategic consultants:**

It emerged from academic and practitioner interviews and survey responses. The examples given by the participants described management and strategic consultants’ viewpoints regarding design:

‘Design is being seen more as a marketing tool by the managers to make people consume.’ (Academic A9, survey, June 2013)

‘Perhaps now we are given more freedom on the brief from the top level of the business whereas before we were looking down to a focus design problem lower down. Design is more strategic.’ (Practitioner P20, interview, December 2013)

These examples were supported by the findings of the literature review; it appeared that there was an interest from the design and business
communities to further interact with one and other. From the interviews and survey findings these phrases belonged to this supporting theme.

**Marketing professionals:**

*Marketing professionals* was identified from academic and practitioner interviews and survey responses. The examples given by the participants described the relationship between marketing professionals and designers:

‘Designers in the past worked for the marketing department, they worked in graphics or product design context, engineering, and technical and so on.’ (Practitioner P14, interview, June 2013)

‘A very fancy word promoted by marketing professionals about the designers’ ability to translate descriptive words into images. It is unclear if a designer or others are employing design thinking when they are designing or when they are thinking about designing. Largely, I believe it is hype.’ (Academic A23, survey, August 2013)

From these examples it appeared that *marketing professionals* were still heavily involved in the design industry. However, their roles today could be different. The evidence suggested that it belonged to the supporting theme.

**Software engineers:**

*Software engineers* emerged from an academic interview when the interviewee gave an overview of the shift from graphic to communication design:

‘The shift from graphic to communication design. That whole side of the import was missing. It is funny if you were to go to ACM and KAI conferences and you were to type in design thinking you get very little in fact what you are seeing is a whole bunch of software engineers desperate to get their hands on qualitative social research methods, more creative generative design method, better ideation strategies so in funny ways in the early 80s-90s and there was a gap because there
was all these people just trying to stomach the wave of technology that was coming...’ (Academic A27, interview, June 2013)

From the example, it appeared that other than designers and practitioners from other fields; software engineers were also interested in understanding and applying design thinking.

5.5.4.3. Impact

Impact was a common characteristic identified from the literature review. The common characteristic had the following meaning: impact was the result of using design thinking to solve the problem identified. In the context researched, impact could be a new product created by using design thinking, an example from the literature would be the creation of Swatch (Verganti, 2009: 68–73). Using Quartz movement, Swatch design a low cost Swiss made watch and introduced the concept of watches as fashion items. Impact could also be competitive advantage over competitors. An example of better performance would be the Brabham F1 suspension design described in chapter 2.4.2. An example of unique selling point of a product would be the extensive use of polymer in Mothercare’s Via Multibuggy when it was launched in the 1980s (see Chapter 2.4.3). These were just a few examples of what impact could be. Same as the previous common characteristics the meaning of impact was used in the axial coding phase of content analysis to identify supporting evidence from the data sets. Tables 36-37 shows the data coded under impact:
<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Development</td>
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<td>IN: A7, A8, A21, P13</td>
<td>6</td>
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</tr>
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</tr>
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<td>OS</td>
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</tr>
<tr>
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<td></td>
<td>OS: A6</td>
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</tr>
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<td></td>
<td>OS: A4, A21, A31, P4, P7</td>
<td></td>
</tr>
<tr>
<td>Tool kit</td>
<td>3</td>
<td>IN: A27, A29, P18</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
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</tr>
<tr>
<td>Product eco, service system</td>
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Table 36 Words coded under the common characteristic impact during content analysis

7 IN: Interviews; OS: Online Survey    A: Academic; P: Practitioner
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Table 37 Words coded under the common characteristic impact during content analysis (Continued from Table 36)

\(^a\) IN: Interviews; OS: Online Survey A: Academic; P: Practitioner
Figure 62 The common characteristic ‘impact’ and its supporting evidence

Figure 62 shows the data coded under impact during axial coding and presents the links between them. From the data two nodes (development and production) had no sub-categories coded under them so they formed part of the evidence but did not become supporting themes. The following became supporting theme as they had data coded under them:

- Ideas
- Outcome
- Product eco, service system
- Strategy
- Value

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.
Ideas

Ideas was coded as a supporting theme for impact because of the meaning of the word from the language point of view and the example given by the participants. An example given by the participants was design thinking being a magical formula of creativity that generates ideas. The evidence suggested ideas was to be coded under impact.

Alternatives

Alternatives was coded under ideas, it emerged from an academic survey response. The participant used it to describe alternative as a result of using design thinking to solve a problem.

Outcome

Outcome was a supporting theme identified from the data gathered. The following were coded under it: adaption, creatively informed decisions, creativity, experience, innovation, integration, knowledge generation, market outcomes, market tool, open-ended outcomes, outputs, profit, solution and tool kit.

Adaption

It was coded under outcome because of the example provided by the participant. The participant stated adaption as part of the outcome of solving a traditional design problem. The evidence suggested it was to be coded under outcome.

Creatively informed decisions

The academic gave an example of the meaning of creatively informed decisions:

‘In particular I see design thinking as the generalization of methodologically making creatively informed decisions, for almost any context.’ (Academic A7, survey, June 2013)
From that example given, it appeared that the phrase belonged to outcome as the example was describing a result of employing design thinking.

Creativity

Creativity emerged from interviews and survey responses given by academics and practitioners. One of the examples provided stated ‘people use design thinking for creativity and innovation’. From the contexts in which the evidence emerged from it was coded under outcome.

Experience

From the context from which the word emerged, the data suggested experience was seen as an end product:

‘Aimed at the psychological goal of an object or event/experience, whether simple or complex.’ (Academic A5, survey, June 2013)

‘User experience is another big system that feeds into it. Partly because of the cross fertilisation from the software industry where the user experience has become a dominate way of thinking. People that design products are now thinking how a product is situated in an entire user experience spectrum rather than on its own.’ (Academic A28, interview, July 2013)

Therefore, it was coded under outcome.

Innovation

From the context from which it emerged, it appeared innovation was seen as an outcome of employing design thinking. Here was an example provided by one of the participants:

‘(...) a lot of people use design thinking for creativity and innovation and thinking outside the box.’ (Practitioner P18, interview, December 2013)

The example above justified coding innovation under outcome.
Social innovation

Social innovation was one of the two phrases coded under innovation. The participants saw it as an outcome of design thinking; therefore, from the evidence provided it was coded under innovation. Below was an example given:

‘So a quick example is that in NYC I was involved in a DESS project so it is a network of researchers concern about design for sustainability and social innovation this particular methodology is that designers don't come up with the good ideas they find good ideas hidden in the community they community has people already innovating sustainable lifestyle.’ (Academic A27, interview, July 2013)

Disruptive innovation

Disruptive innovation was also coded under innovation; it was identified from a group interview with practitioners. The participants used how the first Apple iPod was designed as an example of disruptive innovation. From the example given it made sense to code it under innovation.

Integration

Integration was identified from an academic survey response. It was coded under outcome because of the context in which it emerged from. The academic believe integration was the result of design thinking. Therefore, it was coded it under outcome as suggested by the evidence.

Market outcomes

From the context that the examples emerged from it appeared that market outcomes belonged to outcome. Below was an example given:

‘It is making people realise that it is worthwhile investing in design whatever your industry is whether is consumer products or something completely different needs an aspect of design in to make it sellable and advertising.’ (Practitioner P15, interview, June 2013)
**Marketing tool**

It was coded under *outcome* because both of the academic who responded believed design thinking was being used as a *marketing tool* for businesses. From that point of view, it appeared that the *marketing tool* aspect of design thinking was an *outcome* of employing it.

**Open-ended outcomes**

From the context from which it emerged, the data suggested that it should be coded under *outcome*. In addition to the evidence from the data, literature written by practitioners also suggested that design thinking often created open-ended outcomes (Brown, 2009 and Martin, 2009). As the evidence suggested it was logical to code the phrase under *outcome*.

**Outputs**

It was coded under *outcome* because of the examples that were given by the participants:

‘Yes properly, commercial is more concern with result and money. There is a bias towards can we sell it, is it viable and can we make it a product?’ (Practitioner P17, interview, September 2013)

‘We might look ahead the output might be something a long way down the road map or pipe line the next stage is to bring that closer to home. The less traditional is to see what happens won't have the answer straight away.’ (Practitioner P20, interview, December 2013)

From these examples given it appeared that *outputs* belonged to *outcome*.

**Profit**

From the examples given by the participants, it was cleared that *profit* belonged to *outcome*, as *profit* was a way to quantify the impact of design thinking.
Solution

From the contexts in which it emerged from, it appeared that solutions were an expected outcome of employing design thinking for problem solving. Therefore, it was coded under outcome. Below were some examples provided by the participants:

‘All I can suggest is that it is about looking to generate an acceptable solution from a set of problematic contexts.’ (Academic A4, survey, June 2013)

‘I have used DT in the classroom to frame a collaboration process with students. I have also used DT in corporate settings with a design studio framing business problems and processes to create new cultural solutions inside the businesses.’ (Practitioner P4, survey, June 2013)

Tool kit

It was coded under outcome because of the examples provided. One of the examples provided stated design tool kits were ways that designers communicating their ways of working and knowledge to non-designers.

Product eco, service system

Product eco, service system was the fourth supporting theme emerged from the data gathered. The following was coded under it: industrial products, products, service, service systems and systems.

Industrial products

It was given as part of the responses provided by the participants when asked about their previous experience of employing design thinking. As a result of the contexts in which it emerged from, it was coded under the supporting theme.

Product

Product was coded separately from industrial products because of the examples given by the participants. From the examples given the products that the participants were describing were physical objects rather than
non-physical products such as a service. As a result of these description product was coded separately.

Service

From the context from which it emerged, the participants saw it as an outcome of design thinking as a result it was coded under the supporting theme.

Service system

Despite it being similar to service in terms of meaning, it was coded separately because of the examples given in the interviews. From the interviews, service system was used by the participants to describe services that require a series of interacting and co-operating parties’ to fully function. One participant used the iPhone as an example.

System

From the examples given, it appeared the participants saw system as an outcome of design thinking. Below were some of the examples given:

‘Some interesting thing has happened. I suppose what I noticed something that happened here two years ago is how interested is everyone is in context, systems and ecologies. There is a real awareness amongst staff and students that design don’t exist in isolation.’ (Academic A28, interview, July 2013)

‘Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem.’ (Practitioner P4, survey, June 2013)

Strategy

Strategy was the next supporting theme identified from the data. It was coded under impact because the examples given described it as an outcome of using design thinking:
‘An ill-defined hype term for a general method / strategy in essence what designers have always done.’ (Academic A16, survey response, June 2013)

‘It is a collaborative and multidisciplinary way of looking at, sketching, and proposing new systems and strategies in business, culture, political systems, health systems and the other organizing frameworks that affect our lives.’ (Practitioner P4, survey, response, June 2013)

Creativity formula

It was used by the participant to describe a potential impact that non-designers expect when employing design thinking:

‘From outside design, design thinking is a way to try and understand what designers do, as if somehow it's a magical formula for creativity.’
(Academic A21, survey, June 2013)

From the example provided, it appeared creativity formula belonged to the supporting theme.

Value

Value was the final supporting theme of impact. It was coded under impact because of the evidence from the literature review. Literature written by practitioners (Martin, 2009 & Verganti, 2009) often stated the employment of design thinking was a way of gaining competitive advantage; the advantages gained were often quantified by value in the form of numbers or features. As a result of the evidence provided in the literature value was coded under impact. The following were coded under value: notions of satisfying and unique selling points (USP).

Notions of satisfying

It was coded under the supporting theme because of the participants believed it was a specific outcome of using design thinking as shown in the examples below:
‘One of the things which I think is really important about design thinking for me is that notion of satisfying.’ (Academic A28, interview, July 2013)

‘Let’s be honest we are here to make products that is 99% of time we are here to make a product that is commercial success and make money. Second reason we might be here is we are doing to improve people’s lives that links back to the money thing and people are paying for the product that will improve the quality of life.’ (Practitioner P15, interview, June 2013)

*Unique selling points (USPs)*

*Unique selling points (USPs)* was also coded under value. It was coded under the supporting theme because the participants used it to quantified value created through design activity. From the examples provided it was logical to code it under value.

5.5.4.4. Processes (CC)

Processes (CC) was the final common characteristic identified from the literature review. The common characteristic had the following meaning: Processes (CC) were the strategies, steps or processes developed or used to solve the problems given. In the context researched, examples of process would be the ‘user centred design processes’ or prototyping with CAD and 3D printing. Same as the previous common characteristics the meaning was used in the axial coding phase of content analysis to identify supporting evidence from the data sets. Tables 38-41 present the data that was coded under processes (CC):
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Table 38 Words coded under the common characteristic processes during content analysis

9 IN: Interviews; OS: Online Survey  A: Academic; P: Practitioner
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Table 39 Words coded under the common characteristic processes during content analysis

(Continued from Table 38)

\[10\] IN: Interviews; OS: Online Survey   A: Academic; P: Practitioner

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Table 40 Words coded under the common characteristic processes during content analysis
(Continued from Table 39)

\(^{11}\) IN: Interviews; OS: Online Survey   A: Academic; P: Practitioner
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<td>3</td>
<td>IN A27, A28, A29</td>
<td>5</td>
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<td></td>
<td>OS</td>
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<td>1</td>
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<td>OS</td>
<td></td>
<td></td>
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<td>6</td>
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<tr>
<td></td>
<td>OS</td>
<td></td>
<td></td>
</tr>
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<td>4</td>
<td>IN A27, A29, A35, P17</td>
<td>4</td>
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<td></td>
<td>OS</td>
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<td></td>
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<td>IN P20</td>
<td>2</td>
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<td>OS</td>
<td>P3</td>
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<td>OS</td>
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<td></td>
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<td>IN A36</td>
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<td>OS</td>
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</table>

Table 41: Words coded under the common characteristic processes during content analysis
(Continued from Table 40)

\(^{12}\) IN: Interviews; OS: Online Survey  
A: Academic; P: Practitioner
Figure 63 The common characteristic ‘process’ and its supporting evidence
Figure 63 shows the data coded under the *processes (CC)* during axial coding and present the links between them. From the data, six nodes had no sub-categories coded under them; those were: business process, decision making, problem analysis, problem framing, problem solving and problem understanding. Therefore, they formed part of the evidence but did not become supporting themes. The following became supporting themes as they had data coded under them:

- Cognition
- Creative processes
- Design (verb)
- Innovate, innovative
- Methodology
- Qualitative research

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.

**Cognition**

*Cognition* was one of the supporting themes with the most data coded under it. The following was coded under it: *abductive reasoning, design cognition, deduction, extract and read, fusing people with things, induction, mind-set and thinking*. *Cognition* was coded under *processes (CC)* as a supporting theme because of the meaning of the word. In addition to the meaning of the word, evidence from the literature review and responses from the participants suggested that without cognition there would be no design thinking. Therefore, the word was coded as a supporting theme as suggested by the data. Below was an example:

‘The cognitive act or the kinds of thinking that is employed during design activity or the process of designing and design practice. In commercial setting I have no idea. I suspect the reason for employing design thinking in these workshops maybe try to use it as a method to
get people to think in a certain way or different way about something.’

(Academic A30, interview, July 2013)

Design cognition

Design cognition emerged from an academic interview. From the interview it appeared that the participant was using the phrase to describe the specific way of thinking that designers used. As a result of the example provided, it was coded under cognition.

Disposition

It was coded under cognition because of the examples given in the interview. The interviewee was describing disposition as an important mindset to have when employing design thinking because without it design thinking could not be used to its full potential. Below was the example given:

‘Disposition, design thinking is disposition, I think this idea of do you have a mind-set towards ambiguity or are you developing a cultural creative environment. I feel like you go through a process and driven by human needs and involve experts and create impact but if we don't have design disposition or that openness you are not doing design thinking.’ (Academic A36, interview, August 2013)

Extract and read

From the interviews it appeared the participant used the phrase to describe how designers read a situation when problems were given to them. Therefore, from the example given it was coded under cognition. Below were some examples from the interviews:

‘I think that is crucial kind of component that I would add is that the ability to extract and read. The second one, if goes under the name of Bruno... designers see people as monsters they see them as people plus things.’ (Academic A27, interview, June 2013)

‘As a product designer you don't have to be an expert but you need to be able to extract the right information from experts that is what the
difficulty that what makes you good at communicating and absorbing the right information.’ (Practitioner P15, interview, June 2013)

**Fusing people with things**

The interviewee was using the phrase to describe a cognitive ability that designers appear to have when seeing objects and people together. From the example given the phrase was coded under cognition:

‘Designers see something different when you have glass on and iPhone on your hands. Fusing between people and things is something that designers can see and others can’t.’ (Academic A27, interview, June 2013)

**Mind-set**

The participant used the phrase to describe a certain thought process required to employ design thinking. The example given suggested mind-set was to be coded under cognition.

**Thinking**

It was coded under cognition because of the meaning of the word. Furthermore, thinking also had the most amount data coded under it forming a sub-category. The next section presents the data coded under thinking.

**Academic thinking**

The participant used it to describe the different mind-set behind commercial and academic applications of design thinking:

‘Design is being seen more as a marketing tool by the managers to make people consume. Academic thinking brings in value base of design.’ (Academic A9, survey, June 2013)

It was coded under thinking because of the context in which it emerged from.
Analytical thinking

From the interview the participant listed it as a requirement for creative thinking. Therefore, it was coded under thinking.

Creative thinking

It was coded under thinking because of the examples given by the participants:

‘A trained approach to creative thinking.’ (Academic A12, survey, June 2013)

‘If you think about creative thinking as a whole where does it fit in as creative thinking? Something to look into is creative thinking and design thinking the same thing or people just use creative thinking as a term that brings together lots of different methods? In which case a lot of people use design thinking for creativity and innovation and thinking outside the box.’ (Practitioner P18, interview December 2013)

Some of these viewpoints given appeared to be similar to those identified from the literature review.

Designerly thinking

The participants used designerly thinking to describe the unique ways of how designers think; therefore, it was coded under thinking.

Intuitive thinking

From the interview the participant was listing it as a requirement in order to conduct creative thinking; therefore, it was coded under thinking for that reason.

Lateral thinking

Lateral thinking emerged from an academic survey response. It was used to describe a participant’s view on what design thinking is:

‘I find it very unclear, but would just summarise it as the problem-solving process used by many designers. I suspect it's very similar (or
possibly the same as) creative thinking or lateral thinking.’ (Academic A6, survey, June 2013)

As a result of the example provided, it was coded under thinking.

Logical thinking

It was used by the participant to describe his or her view on what design thinking is. The example given showed the phrase was used to describe a specific mode of thinking; therefore, it was coded under thinking.

Process thinking

Process thinking was identified from an academic survey response (A25). It was coded under thinking because the phrase was used to describe the participant’s viewpoint of design thinking being a combination of a certain way of thinking:

‘The integration of all types of process thinking.’ (Academic A25, survey, June 2013)

Quantitative thinking

It was coded under thinking because the participant used it to describe a certain mode of thinking used by managers:

‘It is the different between a design firm positioning itself as a management and strategic consultant on the ideas part. And Roger Martin attempting to break the dominance of quantitative thinking in business management.’ (Academic A27, interview, June 2013)

System thinking

It was coded under thinking because it was used by the participants to describe a certain mode of thinking. Furthermore, the findings from the literature review showed that some literature written by practitioner claimed that design thinking was a holistic way of problem solving; therefore to successfully employ it, the users must think holistically. This concept was similar to the examples given by the participants; therefore,
from the findings it appeared systems thinking was to be coded under thinking.

*Technological thinking*

It was used by the participant to describe the requirement of a creative mind. It was coded under thinking because of it being used by the participants to describe a certain mode of thinking.

*Thinking about design*

From the response given by the participants the phrase was used to describe the cognitive act of thinking about design or describing what they believed design thinking was. Therefore from the way the phrase was used, it was coded under thinking.

*Visual thinking*

From the interviews it appeared that the participants were using the phrase to describe a certain way thinking that heavily relied visuals. As a result of the contexts in which the examples were identified it was coded under thinking:

‘Normally if you just use to spared sheets and charts and word documents with tables. You end up with a standardise curriculum it is only begin when you use a richer visual thinking that you actually come up with more interesting things.’ (Academic A27, interview, June 2013)

*Creative processes*

Creative processes was another supporting theme identified from the data. The following were coded under it: brainstorming and combination of creative instinct and research methodologies. A number of participants also stated design thinking being a creative process of creating innovation and new services; therefore, according to the examples given it appeared to belong to processes. In addition to the findings from the interviews and surveys, data from the literature review suggested that literature written by practitioners often presented design thinking as a creative process (Berger, 2009; Martin, 2009; Nussbaum, 2013);
therefore, from that viewpoint, it made sense to code it under *processes* as a supporting theme.

*Brainstorming*

It was coded under the supporting theme because of the examples given; the examples stated *brainstorming* is a creative technique that is use for generating ideas. The data suggested it was to be coded under *creative processes*.

*Combination of creative instinct and research methodologies*

It was coded under *creative processes* because it was used to describe the participant’s views of what design thinking is.

*Design (verb)*

The supporting theme was identified regularly throughout the data. *Design process* was the only phrase to be coded under the supporting theme; however, plenty of data was coded under *design process*. The next section presents them in detail. *Design (verb)* was coded under *processes* because of the meaning of the verb and the contexts in which it emerged from. The examples given suggested the participants were talking about the act of designing. Below is an example:

> ‘At the moment I am trying to set up a serious of workshop trying to expand my business. I got product and service design but I don't want to spend all my life designing stuff for people’ (Practitioner P17, interview, September 2013)

*Design process*

*Design process* was the only phrase coded under the supporting theme. It was coded under the supporting theme because of the examples given by the participants:

> ‘Design thinking is the application of design process and methods inside and outside typical contexts.’ (Academic A7, survey, June 2013)
‘A design process that originates from the user’s POV and grows through brainstorming, collaboration, and prototyping.’ (Practitioner P8, survey, June 2013)

The following was coded under design process: co-creation and participatory design, co-design, design methods and methodology, generative design, ideas creation, multidisciplinary design, new product development, prototyping, sketching, styling and user centred design.

Co-creation and participatory design

The two phrases were put together because the evidence from the data suggested they had a similar meaning to each other. Co-creation and participatory design were used by the participants to describe design processes that heavily involve users when creating the solutions to the problems. The examples given appeared to suggest co-creation and participatory design belonged to design process.

Co-design

It was coded separately to the previous node (co-creation and participatory design) because it was different to it as shown by the example given:

‘Co-design is kind of like that where you facilitate an environment where creativity can flourish but then your knowledge and skills kind of push it or lean it on bits that have potential from your knowledge or experience or push for bits that you are interested in even.’
(Practitioner P17, interview, September 2013)

From the example, it appeared that co-design was a design process commonly used and it had a different meaning to co-creation; therefore, it was coded separately to the previous node.

Design methods and methodology

It was coded under the supporting theme because the phrase was used by the participants to describe specific methods used by designers.
Therefore, the contexts in which the data originated from suggested it was to be coded under *design process*.

**Generative design**

It was coded under *design process* because the interviewee used it to describe a specific way of designing:

‘(...) Liz Sanders kind of generative design where it is verging on participatory design early fuzzy front end of those processes. I would say that is the difference and the space between those two has not been bridge either academically or in the commercial sense.’

(Academic A27, interview, June 2013)

**Ideas creation**

It was coded under *design process* because the participants used the phrase to describe design thinking’s purpose of creating ideas and generating solutions.

**Multidisciplinary design**

The participant used the phrase to describe the possible processes used during an open-ended multidisciplinary design project. As a result of the processes described it was coded under *design process*.

**Prototyping**

It was coded under *design process* because of the findings from the literature review and the data gathered. The literature review findings suggested *prototyping* to be an important part of the *design process*. The data gathered from interviews and survey also provided evidence in a similar light; therefore, it was logical to code *prototyping* under *design process*.

**Sketching**

*Sketching* was coded under *design process*. Literature written by academics suggested *sketching* was a vital visualisation and communication tool used by designer; therefore from that point of view, it
was logical to code sketching under design process. In addition to the literature review findings, the interviewee stated sketching was an important visualisation tool when practicing industrial design.

**User centred design**

The participants used the phrase to describe a certain ways of designing that required users’ participation:

‘On the process you have user centred design approach, for me I would put user centred as a driver that is my view. And processes are more like the techniques for getting it done.’ (Academic A36, interview, August 2013)

‘I think the basic principles user centred approach, empathic with consumers at the start, it is very similar process that you use to develop products, you just apply that to different sectors is what I think is really interesting.’ (Practitioner P20, interview, December 2013)

From the examples above it appeared that user centred design was to be coded under design process.

**Innovate and innovative**

It was coded under design process because the participant used it to describe what design thinking does:

‘Stronger forms of design thinking may be employed in a more definitive way, often resulting in the framing of a problem that is unexpected and innovative.’ (Practitioner P2, survey, June 2013)

**Innovation management**

It was used by the participant to describe how business schools in American Universities portrayed design thinking:

‘They basically rephrase that are already in innovation management literature and it is exactly the same stuff. Just put the word design here and there. They have not engaged the design discipline to understand what design could bring, innovation management was a bit stall and
this was the way to give it a 2nd life or 3rd life. It is some techniques in there that designers used but those have been in innovation management before there. It is nothing new at all.’ (Academic A35, interview, August 2013)

**Methodology**

Despite its possible similarities to design process, it was coded separately because the examples given by the participants were not specifically describing design methods or processes:

‘Methodology for transdisciplinary problem solving.’ (Academic A11, survey, June 2013)

‘We used a transdisciplinary approach. We used a local mind-set with our own methodologies that are better adapted to peripheral design practices.’ (Practitioner, P13, survey, June 2013)

The examples given showed a difference to those given for design process; as a result, it was coded separately.

**Methodological driven process**

It was coded under the supporting theme because the interviewee used it to describe the methodology used to solve a changeable social problem.

**Qualitative research**

Qualitative research was the final supporting theme identified from the data. The following was coded under it: empirical research, mapping, observation, research by design, research design, research for design, research of design, role playing and theory construction. Qualitative research was coded as a supporting theme because of the data that was coded under it. The data coded under it provided evidence suggesting qualitative research are part of the processes used within design thinking.

**Empirical research**

The interviewees used the phrase to describe a specific way of conducting research that involved observation and experiments. Therefore, the
meaning of the phrase and the examples provided appeared to suggest it belong to the supporting theme.

**Mapping**

The interviewee used it to describe a specific research technique; therefore, it was coded under the supporting theme:

> ‘Cognition is about mapping experience of observation in the world, plus thoughtfulness plus perception of what might be comes in.’
> (Practitioner P14, interview, June 2013)

**Observation**

It was coded under *qualitative research* because it was a *qualitative research* technique. Furthermore, the interviewees stated it was a research technique that they employed regularly during design projects.

**Research design**

From the interview the academic was using to describe the act of designing research activity; therefore, it was coded under *qualitative research*.

**Research by design**

It was used by the interviewees to describe research activity conducted by designers or designer researchers:

> ‘I am not sure what exactly would it mean for academics to apply design thinking other than in the second meaning I indicated which is academics taking a design approach to how design conducts research.’
> (Academic A29, interview, July 2013)

It was coded under *qualitative research* because of the examples provided by the participants.

**Research for design**

*Research for design* was identified from examples given by the participants when they were discussing the difference between
commercial and academic design research. The examples provided argued that research for design was the commercial version of research by design:

‘If you are doing design thinking research you would just get on with it, allocate this amount of time and there won't be a sense of urgency I would have thought. Get your results; the reason of doing it would be getting the results. If you are doing it commercially you would speed it up and refer to stakeholders for progress update. They would get upset because they wouldn't understand what an ambiguous process it is anyway but any result you come out at the end would have to be numbers or commercial and sold no matter what it is. In academia the results you can report, whereas in commercial environment the results you can sell. There is a different attitude and direction towards it.’ (Practitioner P17, interview, September 2013)

Research of design

The participants used the phrase to describe research towards design conducted by those who were interested in understanding what design was:

‘So I normally take academic to be research focused so the application of design thinking in any of those meanings for research project would be different to a commercial project for example as products have end points.’ (Academic A29, interview, July 2013)

‘I think that design research, serious design research trying to find out what are the features of design and design practices and how do they work.’ (Academic A35, interview, August 2013)
5.5.4.5. ‘Design problem,’ traditional or non-traditional

‘Design problem’, traditional or non-traditional was a common characteristic identified from the pilot studies. It was identified from content analysis conducted on the pilot’s data. It had the following meaning: this characteristic described the nature of the problem identified. In the context researched, a traditional design problem would be designing a new range of power tools to increase the brand’s market share. A non-traditional design problem would be using design to increase the detection rate of potential terror suspects at airports. The examples were identified from the literature review and case studies analysis. Same as the previous common characteristics the meaning was used in the axial coding phase of content analysis to identify supporting evidence from the data sets. Tables 42-43 present the data that was coded under ‘design problem’, traditional or non-traditional:
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<td></td>
<td>OS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End to end</td>
<td>1 IN</td>
<td>P14</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>OS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ill-defined problems</td>
<td>2 IN</td>
<td>A30</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>OS</td>
<td>P12</td>
<td></td>
</tr>
</tbody>
</table>

Table 42: Words coded under the common characteristic ‘design problem’, traditional or non-traditional during content analysis

\(^{13}\) IN: Interviews; OS: Online Survey  
A: Academic; P: Practitioner

235
<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open ended problems</td>
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<td>2</td>
</tr>
<tr>
<td>Public sector</td>
<td>2</td>
<td>IN P19</td>
<td>3</td>
</tr>
<tr>
<td>challenges</td>
<td></td>
<td>OS A31</td>
<td></td>
</tr>
<tr>
<td>Policy</td>
<td>6</td>
<td>IN A27, A28, A29, A35,</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P18</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>4</td>
<td>IN P17</td>
<td>7</td>
</tr>
<tr>
<td>Healthcare</td>
<td>1</td>
<td>IN P19</td>
<td>1</td>
</tr>
<tr>
<td>Social problem</td>
<td>5</td>
<td>IN A27, A29, A35, A36,</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P17</td>
<td></td>
</tr>
<tr>
<td>Social and</td>
<td>1</td>
<td>IN A27</td>
<td>1</td>
</tr>
<tr>
<td>ethnography light</td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>1</td>
<td>IN A17</td>
<td>1</td>
</tr>
<tr>
<td>situation</td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Non-traditional</td>
<td>9</td>
<td>IN A27, A28, A29, A30,</td>
<td>23</td>
</tr>
<tr>
<td>design problem</td>
<td></td>
<td>OS A35, A36, P15, P17,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P18, P20</td>
<td></td>
</tr>
</tbody>
</table>

Table 43 Words coded under the common characteristic ‘design problem’, traditional or non-traditional during content analysis (Continued from Table 42)

14 IN: Interviews; OS: Online Survey  A: Academic; P: Practitioner
Figure 64 The common characteristic ‘design problem’, traditional or non-traditional and its supporting evidence
Figure 64 shows the data coded under ‘design problem’, traditional or non-traditional during axial coding and presents the links between them. From the data, problem context, domains was the only node coded under the common characteristic. The following was coded under problem context, domains and became supporting themes with additional data coded under them:

- Design context, domain
- Non-design context

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.

**Design context, domains**

From the responses given the supporting theme had the meaning of traditional design problems; the meaning was identified from the examples provided by the participants:

‘A traditional design problem is a requirement that the designer whether human or some other agent. That the designer generate the specification if followed would enable change. Change in a required way.’ (Academic A29, interview, July 2013)

‘I'm not sure in what sense you are using the word "traditional"—historically, this term has been used to define non-wicked problems, and in that case, very few "traditional" design problems actually exist. "Traditional" may also represent traditional contexts of design, such as product, visual, or architectural design.’ (Practitioner P2, survey, June 2013)

From the examples given, it appeared that from the participants' viewpoints, traditional design problems were mainly to do with designing products that had a physical presence. In addition, the examples also described the setting of traditional design problems, where a problem or opportunity was identified then a solution was designed to solve that given problem. The following were coded under the supporting theme:
design challenges, design problems, design science, learning problem and wicked problems.

Design challenges

The interviewees used the phrase to describe design problems that they have encountered during their careers. As a result, it was coded under the supporting theme.

Design problems

It was coded under the supporting theme because the participants used it to describe what they believed to be traditional design problems. Below were some examples given:

‘For me a traditional design problem is, defining learning problem someone has and creating a pathway to address that learning problem.’ (Academic A36, interview, August 2013)

‘Traditional design problem, make a chair that fits everybody. It is not possible or it is very hard or it might be possible.’ (Practitioner P17, interview, September 2013)

Design science

It was coded under the supporting theme because the participant used it to describe his or her view of what a traditional design problem was:

‘Academic design science is far more rigorous in the creation of artefacts and of evaluation the utility of artefacts compared to design thinking. Also academic design science must, given all design is normative, make every attempt to being transparent about how design decisions were made - based on descriptive science literature; practical requirement or personal world view of the designer/research.’ (Practitioner P5, survey, June 2013)
Learning problem

Learning problem was identified from an academic interview. From the participants’ experience, the learning problems he encountered were traditional design problems; therefore, it was coded under the supporting theme because of the examples given.

Non-design context

Non-design context was the second supporting theme of the characteristic. From the responses given, the supporting theme had the meaning of problems outside a design context or belonged to other disciplines. The following phrases were coded under the supporting theme: business, complex problems, fuzzy front end, public sector challenges, and social.

Business

It was coded under the supporting theme because it was a different discipline to design. The following phrases were coded under business: business problems and commercial.

Business problem

Business problem was identified from a practitioner’s survey response. From the response, it appeared that the participant was using it to describe problems within the business context:

‘For 15 years I was a business architect - using the levels of business process design, job / organization design and technology design to solve business problems.’ (Practitioner P5, survey, June 2013)

Commercial

The word was used by the participants to describe the environment that design thinking could be applied in as a result it was coded under the supporting theme.
Complex problems

It was coded under the supporting theme because the participants were using the phrase to describe problems outside design that were complex:

‘The problem with a term like design thinking is that it used to claimed too much for the design disciplines as if designers are the only ones that can deal with complex social problems.’ (Academic A35, interview, August 2013)

The following were coded under complex problems: empathetic, fuzzy front end holistic, ill-defined problem, incorrectly specified, open-ended problems and unsatisfactory situation.

Empathetic

It was coded under complex problems because the participant listed it as a factor of understanding and solving complex problems.

Fuzzy front end

It was coded under complex problems because it was often used in literature to describe the start of complex problems. In addition, the participants also shared similar viewpoints to the literature findings.

Holistic and end to end

The interviewee used the phrases to describe the complexity of a system. The example given suggested they were to be coded under complex problems:

‘Systems thinking look at inputs and output across a whole system. It includes not the just processes but the resources, the technology and it is holistic from end to end. I thinking design thinking also take that approach let’s look from end to end which is why starts off at defining the right questions.’ (Practitioner P14, interview, June 2013)

Ill-defined problems
It was coded under complex problems because the participants used it to describe complex problems:

‘We are having difficulties in X. Can you help us? (Where X is either ill-defined or incorrectly specified)’ (Practitioner P12, survey, June 2013)

Open-ended problems

It was coded under complex problems because the participants were using it to describe complex multidisciplinary problems that were beyond any specific design disciplines.

Public sector challenges

It was coded under complex problems because the findings from the literature review suggested that public sector challenges were often seen as complex problems. Furthermore, the evidence provided by the participants also supported the viewpoints expressed in the literature. The interviewees used the NHS reforming as an example.

Policy

It was coded under public sector challenges because often policies were outcomes towards problems identified in the public sector.

Social

It was coded under the supporting theme because social problems were not seen as traditional design problems. Furthermore, the examples given by the participants suggested coding it under the supporting theme:

‘Fragmented process dependent on sociocultural circumstances.’ (Academic A33, survey, August 2013)

‘The Drivers in my work are social and cultural conditions, not market conditions. For example, the cultural condition of downtown Phoenix last year for bicycles was apathy or disengagement.’ (Practitioner P4, survey, June 2013)
Healthcare

It was coded under social because the findings from the literature review (Brown, 2009; 117–118 & 169) suggested that healthcare was a non-traditional design problem that could be solved by design thinking. In addition, the participants also believed healthcare was a problem that can be tackled by design thinking; therefore, it made sense to code it under social.

 Unsatisfactory situation

It was coded under complex problem because the academic used it to describe what he or she thought was a non-traditional design problem:

‘A project that seeks to improve an unsatisfactory situation or practice.’
(Academic A17, survey, June 2013)

5.5.4.6. Multidisciplinary

Multidisciplinary was a common characteristic identified from thematic analysis. The common characteristic had the following meaning: multidisciplinary means the disciplines which the experts belong to. In the context researched, an example of a project that was multidisciplinary was the TSA Security Checkpoint Evolution by IDEO from the literature review (Brown, 2009: 185–188 & IDEO, 2013). The disciplines where the expertise came from were design, security and transportation. Same as the previous common characteristics the meaning was used in the axial coding phase of content analysis to identify supporting evidence from the data sets. Tables 44-45 show the data that was coded under multidisciplinary:
<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design practice</td>
<td>8</td>
<td>IN(^{15}) A27, A28, A29, A30, A35, P15, P16</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS A4</td>
<td></td>
</tr>
<tr>
<td>Analogue design</td>
<td>1</td>
<td>IN P15</td>
<td>3</td>
</tr>
<tr>
<td>Architectural design</td>
<td>3</td>
<td>IN A29, A35</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P2</td>
<td></td>
</tr>
<tr>
<td>Brand design</td>
<td>6</td>
<td>IN A27, A29, A35, P15, P19</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS A3</td>
<td></td>
</tr>
<tr>
<td>Business design</td>
<td>3</td>
<td>IN A29, A35, A36</td>
<td>5</td>
</tr>
<tr>
<td>Car design</td>
<td>1</td>
<td>IN P15</td>
<td>1</td>
</tr>
<tr>
<td>Communication design</td>
<td>5</td>
<td>IN A27, A28, A29, A35, A36</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Conceptual design</td>
<td>2</td>
<td>IN A29, A35</td>
<td>4</td>
</tr>
<tr>
<td>Curriculum design</td>
<td>3</td>
<td>IN A27, A29, A35</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Design for emotion</td>
<td>1</td>
<td>IN A29</td>
<td>2</td>
</tr>
<tr>
<td>Design management</td>
<td>4</td>
<td>IN A27, A29, A35, P16</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Digital design</td>
<td>2</td>
<td>IN A28, P15</td>
<td>4</td>
</tr>
<tr>
<td>Embodiment design</td>
<td>2</td>
<td>IN A29, A35</td>
<td>3</td>
</tr>
<tr>
<td>Engineering design</td>
<td>1</td>
<td>IN A29</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Fashion design</td>
<td>3</td>
<td>IN A29, A35, P15</td>
<td>4</td>
</tr>
<tr>
<td>Graphic design</td>
<td>5</td>
<td>IN A27, A29, A35, P14, P15</td>
<td>7</td>
</tr>
<tr>
<td>Industrial/ product design</td>
<td>9</td>
<td>IN A29, A30, A35, A36, P14, P15, P17</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS A3,P2</td>
<td></td>
</tr>
</tbody>
</table>

Table 44 Words coded under the common characteristic multidisciplinary during content analysis

\(^{15}\) IN: Interviews; OS: Online Survey   A: Academic; P: Practitioner

244
### Table 45 Words coded under the common characteristic multidisciplinary during content analysis (Continued from Table 44)

<table>
<thead>
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<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction design</td>
<td>6</td>
<td>IN(^{16}) A27, A29, A30, A35, P15, P16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Service design</td>
<td>4</td>
<td>IN A27, A29, A35, P17</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
</tr>
<tr>
<td>Strategic design</td>
<td>3</td>
<td>IN A27, A29, A35</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS</td>
<td></td>
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<tr>
<td>Visual design</td>
<td>3</td>
<td>IN A29, A35</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OS P2</td>
<td></td>
</tr>
</tbody>
</table>

\(^{16}\) IN: Interviews; OS: Online Survey  
A: Academic; P: Practitioner
Figure 65 The common characteristic multidisciplinary and its supporting evidence
Figure 65 shows the data coded under *multidisciplinary* during axial coding and the links between them. From the data, the only node to be coded under the supporting theme was design practice and it became the only supporting theme identified for this common characteristic.

The following section presents nodes that had examples provided by the participants to further the understanding behind their meaning.

*Design practice*

*Design practice* was the only supporting theme to be identified under the characteristic. Plenty of data were coded under the supporting theme; therefore, the most relevant data with references towards literature review were selected as supporting evidence for the theme. The following were selected as evidence for the supporting theme: *brand design, business design, communication design, curriculum design, design management, graphic design, industrial/product design, interaction design, service design* and *strategic design.*

*Brand design*

The participants stated *brand design* being and important aspects of creating new products. The importance emphasised by the participants was why the discipline was selected.

*Business design*

*Business design* was identified from academic interviews. Literature written by practitioners (Berger, 2009; Brown, 2009; Martin, 2009) seemed to encourage those in business to embraced design thinking and integrate it into its operations.

*Communication design*

It was selected as supporting evidence because the examples given by the participants described it being an aspect of which design thinking could be generating solutions for:
'The movement from CAD through to user centred design to interaction kind of a rival to UX which then blended on the West Coast of US with experience design, branding and communication design that lot. The shift from graphic to communication design.' (Academic A27, interview, June 2013)

Curriculum design

The interviewees gave examples of them designing curriculums as examples of them employing design thinking. Therefore, from that point of view it was suitable to select it as evidence for the supporting theme. In addition, literature evidence also suggested design thinking can be taught then it would be reasonable to believe curriculum design could be seen as a discipline of design practice.

Design management

From literature, design management was seen as an important aspect of any design activity as it managed design at corporate and project level (Best, 2006; 12). This description given by Best fitted well alongside design thinking literature written by practitioners. In addition to the literature findings, it was selected as evidence for the supporting theme because the interviewees provided examples that shared a similar point of view.

Graphic design

It was selected as evidence for the theme because it was another discipline within the data that had a strong presence.

Industrial/ product design

This was the most mentioned discipline coded under the supporting theme. Industrial/ product design was mentioned the most because it was the discipline where some of the participant came from as well as the disciplines where the participants provided plenty of design thinking application examples.
**Interaction design**

Similar to graphic design, it had a strong presence within the data of the supporting theme. *Interaction design* was identified as one of the evidence because the interviewees saw it as an important aspect of today’s design industry:

‘When you look at a traditional design problem is something like the OXO Good Grip. The issue around gripping something and in fact the woman thumb was getting stiff there is an issue there how do we solve that where as a less traditional one would be how to interact with something. Traditional design problem there is an issue again a more tangible issue.’ (Practitioner P15, interview, June 2013)

**Service design**

It was included as evidence because some participants used service design as examples of design thinking application.

**Strategic design**

It was coded as part of the evidence because the interviewees stated it as a way for some design consultancies to describe the services they provide to solve large scale problems. Furthermore, the interviewees also used it to describe how some design consultancies portray design thinking to their clients.

**5.5.4.7. Knowledge**

*Knowledge* was the final common characteristic to be identified. It was identified from thematic analysis. The characteristic has the following meaning: knowledge was provided by experts to help generate the suitable solutions to the problems identified. In the context researched an example of knowledge used in a project to generate a suitable solution was one of the design projects identified from the literature review: the Mothercare Via Multibuggy. The Via Multibuggy’s unique selling point when launched in the 1980s was its material use. It was the first buggy to incorporate a mixture of polymer and metal. The material choice came
from the lead designer’s previous experience working with polymers. As a result of this knowledge the design team was able to create a new buggy based on using polymer as the main material. Despite being identified from thematic analysis, the content analysis yielded relatively little examples. To ensure this common characteristic’s reliability it will be thoroughly analyse again during case study analysis. Table 46 shows the data coded under the common characteristic:

<table>
<thead>
<tr>
<th>Words</th>
<th>Number of sources</th>
<th>Sources</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>7</td>
<td><strong>IN</strong> A30, P17</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong> A5, A6, A24, P2, P5</td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>2</td>
<td><strong>IN</strong> A27, P15</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>T shape</td>
<td>1</td>
<td><strong>IN</strong> A27</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>Descriptive Science</td>
<td>1</td>
<td><strong>IN</strong></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>Technical aspects and expertise</td>
<td>1</td>
<td><strong>IN</strong> A27</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>Designerly way of knowing</td>
<td>1</td>
<td><strong>IN</strong> A30</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>‘First tradition’</td>
<td>1</td>
<td><strong>IN</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
<tr>
<td>Cognitive Science</td>
<td>1</td>
<td><strong>IN</strong> A27</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>OS</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 46 Words coded under the common characteristic knowledge during content analysis

17 **IN**: Interviews; **OS**: Online Survey  
**A**: Academic; **P**: Practitioner
5.5.5. Content analysis findings – exploring if design thinking is thinking done by designers

In addition to identifying evidence of the common characteristics; content analysis was also conducted to answer the research objective 2, if design thinking is thinking done by designers and its research questions:

5. How is design thinking expressed?

6. Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?

7. Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?

In order to answer RQ5, design thinking’s modes of expression must be established. From the original literature review, there appeared to be evidence suggesting there are a number of ways design thinking can be expressed.

Using the findings from the initial literature review as guidance, an additional literature review was conducted alongside grouping similar words and phrases together within the data during content analysis. The following modes of expressions were identified from the literature reviews: graphicacy, language, numeracy, physicality and process (ME). The purpose of the content analysis was to ensure the finding’s reliability and gather additional evidence to support the discovery of the modes of expressions. From the data analysis two forms of evidence were identified; direct evidence meant examples of the modes of expressions were identified by the participants. Interpretative evidence meant no examples were given but the researcher was able to make sense of the data via literature or personal experience. The following sections present these modes of expression and their evidence in detail.
5.5.5.1. Graphicacy

From the findings of the initial literature review, cognitive modelling was identified as a key component to any design activity, Archer (1992) stated that ‘imaging’ is the ability to construe sense data and construct representations spatially and presentationally rather than discursively and sequentially. ‘Imaging’ is an important cognitive ability for designers as one of its forms of expression is via visual output therefore it could be argued that there are aspects of design thinking that can only be expressed visually. Baynes (2013: 100–103) provided a selection of physical properties, aesthetic qualities and spatial relations that are difficult or impossible to convey in natural language: colour, space, form and shape, pattern and proportion. Visual communication appeared to be the way to express and communicate those qualities effectively. Visual communication appears to be a way of expressing design thinking as shown by Cross (2011: 13):

“...I use drawing as a process of criticism and discovery.” Here, MacCormac is saying that he uses drawing both as a means of imaging, imagining or discovering something that he cannot construct just in his mind, and as a means of communication.’

The example provided by Cross (2011: 13) showed visuals as a way of expressing a designer’s thought. Berger (2009: 73-74; 189) stated sketching allows fast and freedom exploration of multiple ideas and ‘make hope visible’ as a way to visualise ideas. Ambrose and Harris (2010: 78-79; 84-91) stated sketching, thinking in images and thinking in signs as ways communicate and apply design thinking. The examples identified from literature show visuals appear to be a way of expressing design thinking. Using that as a starting point further literature review was conducted to establish a term to represent this mode of expression.

From the additional literature reviewed, the term graphicacy was identified. The meaning of the term made it suitable for representing the mode of expression. Graphicacy’s meaning is the ability to understand, read and create still visual images other than words/ letters or numbers,
as a means of communication. Example of those can include maps, diagrams, drawings and flow diagrams (Danos, 2011; 18). Danos' definition of graphicy provided a good guideline of the possible forms of visual expression of design thinking. Figure 66 shows a model spray paint colour guide, an example of graphicy.

The example showed that in addition to words and paint code number (TS on the guide); the actual colours were also presented. While it could be said that using words to describe the colours would have been sufficient.
enough; however, with the similarities in terms of shade and composition of some colours using just words and numbers were not sufficient enough. An example of that need of graphicacy to express colours on the chart would be the closeness of two types of blue paint (mica blue and racing blue) offered as shown in Figure 67:

![Figure 67 Tamiya mica blue and racing blue paints (Tamiya USA, 2015)](image)

The figure shows that the difference between the two shades of blue is relatively minimal. In fact from the online colour guide it is extremely difficult to tell the difference between them; it would appear that using just words to describe the two types of blue would not be sufficient as the words do not give a clear description of what the composition of the colours.

Using the meaning and evidence identified from the literature Tables 47-49 present the supporting evidence for graphicacy identified from the data gathered:
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P: practitioner)</th>
<th>Direct evidence:&lt;sup&gt;18&lt;/sup&gt;:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product (Impact)</td>
<td>Interviews (A27, A29, P14, P18, P19, P20) and survey (A2, A4, A7, A8, A18, P2)</td>
<td>Sony Walkman and its colour: It is like the Walkman story as well, the consumer want it red, blue and green etc... These colours are amazing right now pick up the one you want to go home with, they all picked the black one. (P19, interview)</td>
<td></td>
</tr>
<tr>
<td>Product eco system (Impact)</td>
<td>Interviews (A35, A36, P14, P15, P17) and survey (P3)</td>
<td>Product service system for the national post office: Designing product service systems of the national post office. (P3, survey)</td>
<td></td>
</tr>
<tr>
<td>Service/ service system (Impact)</td>
<td>Interviews (A27, A29, A35, A36, P17) and survey (A3, P2, P4)</td>
<td>Digital services: (...) digital services overlapping provider, platform, thinking of your iPhone as a service system which you have a whole series of cooperating, competing players and a whole series of user intentions. (A27, interview)</td>
<td></td>
</tr>
<tr>
<td>Tool kit (Impact)</td>
<td>Interview (A27, A29, P18, P19, P20)</td>
<td>IDEO, Human-centred design tool kit and design thinking for educators tool kit.</td>
<td></td>
</tr>
<tr>
<td>Marketing tool (Impact)</td>
<td>Survey (A6, A9)</td>
<td>An advertising campaign</td>
<td></td>
</tr>
<tr>
<td>Prototyping (Processes [CC])</td>
<td>Interview (A27, A28) and survey (A21, A31, A33, P8)</td>
<td>Paper mock ups of service touch points and on screen mock ups of mobile application interfaces</td>
<td></td>
</tr>
<tr>
<td>Sketching (Processes [CC])</td>
<td>Interview (P15)</td>
<td>The skill of sketching: (...) you can practice sketching and stuff, lots of it comes down to talent and observing what is current. (P15, interview)</td>
<td></td>
</tr>
</tbody>
</table>

Table 47 Supporting evidence of graphicacy

<sup>18</sup> Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence19:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping (Processes [CC])</td>
<td>Interview (P14)</td>
<td>Explaining the meaning of cognition Cognition is about mapping experience of observation in the world, plus thoughtfulness plus perception the what might be comes in. (P14, interview)</td>
<td>Using photographs to create a customer journey map when creating a new service</td>
</tr>
<tr>
<td>Observation (Processes [CC])</td>
<td>Interview (P14)</td>
<td>Explaining the meaning of cognition (see above)</td>
<td>Using photographs or videos to record the data visually</td>
</tr>
<tr>
<td>Design context, domain (‘Design problems’, traditional or non-traditional)</td>
<td>Interview (A28, A29, A30, P15, P16, P17, P18, P19, P20) and survey (A7, P2, P5)</td>
<td>Traditional contexts of design: &quot;Traditional&quot; may also represent traditional contexts of design, such as product, visual, or architectural design. (P2, survey)</td>
<td></td>
</tr>
<tr>
<td>Design challenge/problems (‘Design problems’, traditional or non-traditional)</td>
<td>Interview (A27, A29, A30, A35, A36, P17) and survey (A17, A26, P1, P2, P4, P7)</td>
<td>A traditional design challenge: (...) the designing disciplines have been originally defined by the material they used like pottery and then the product that comes out like product design or fashion. This is the traditional design challenge, we got to make something like that like this, define by material. (A35, interview)</td>
<td></td>
</tr>
<tr>
<td>Brand design (Multidisciplinary)</td>
<td>Interview (A27, A29, A35, P15, P18, P19, P20)</td>
<td>An example of successful brand creation and design: Another one would be the Innocent Smoothies and it did lots of consumer testing, should we do this yes, because the consumer like the brand. (P20, interview)</td>
<td>Logo design and shared design features or language throughout product ranges; for example the front grills of Ford cars.</td>
</tr>
</tbody>
</table>

Table 48 Supporting evidence of graphicacy (Continued from Table 47)

19 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication design (Multidisciplinary)</td>
<td>Interview (A27, A28, A29, A35)</td>
<td>Outcomes of a traditional design problem: It is still traditional design someone expecting and there should be an artefact but not sure if it was a product, system or environment or communication. (A27, interview)</td>
<td>Graphics on road signs and user interfaces of computer software</td>
</tr>
<tr>
<td>Curriculum design (Multidisciplinary)</td>
<td>Interview (A27, A28, A29, A35)</td>
<td>An example of design thinking application from the interviewee: A second example would be just mainly because most of the work I done is there. Curriculum design when you bring diagramming and visual thinking to curriculum design it does something very interesting to a way you begin thinking about curriculum. (A27, interview)</td>
<td></td>
</tr>
<tr>
<td>Graphic design (Multidisciplinary)</td>
<td>Interview (A27, A29, A35, P14, P15)</td>
<td>Contexts in which designers worked in: Designers in the past in the past worked for the marketing department, they worked in graphics or product design context, engineering, and technical and so on.</td>
<td>Promotional posters for movies and magazine covers</td>
</tr>
<tr>
<td>Industrial/ product design (Multidisciplinary)</td>
<td>Interview (A29, A30, A35, A36, P14, P15, P17) and survey (A3, P2)</td>
<td>What designers do: (...) design adds value to product and therefore people think that product designers make anything from fashion to products and anything that designer made is more expensive. (P15, interview)</td>
<td></td>
</tr>
<tr>
<td>Service design (Multidisciplinary)</td>
<td>Interview (A27, A29, A35, P17)</td>
<td>How do you create a service: People use product design to do a web that is a service. (P17, interview)</td>
<td>Service touch points, they can be information leaflets or promotional material.</td>
</tr>
</tbody>
</table>

Table 49 Supporting evidence of graphicacy (Continued from Table 48)

20 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
5.5.5.2. Language

Figure 68 An example of language; the words ‘design’ and ‘thinking’ written in five different languages

The findings from the initial literature review suggested that designers need to think about words as it is an important way of to communicate and elements of design (Ambrose and Harris, 2010: 108). An example of provided was the communication of brand identity through words (Ambrose et al, 2010: 109). The findings also suggested words and language are important aspects within design (Ambrose et al, 2010: 110-119); therefore, it was reasonable to believe language is a way to express design thinking.

Upon the review of additional literature, language was the second mode of expression identified. Using the literature evidence the following meaning for language was established: language is the communication between people using spoken or written words. Baynes (2013) pointed out:

The designer uses his intelligence to envisage – image – the future and uses models to help in the task. The models are frequently visual,
often mathematical but they can in principle take any form that will help to get the job done. In practice, the information needed in a particular piece of design work maybe wide-ranging and take many different forms: equally the outputs needed to realise a project maybe visual, numerical or linguistic according to need.

Analysing Baynes’s statement it appeared that language played a part in communicating design to others. Baynes’ statement fitted well with some of the definitions of design thinking created by practitioners in the literature review. With some practitioners claiming design thinking has the ability of being integrated into any business or society (Berger, 2009: 5; Brown, 2009: 3); it would be reasonable to expect the certain aspects of design thinking was expressed through language. Should the claims that design thinking could be taught to the non-design sectors be correct, then it would be reasonable to expect those who are teaching design thinking using language as one of the tools to get the job done. Tables 50-51 present the supporting evidence for language identified from the data gathered:
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P: practitioner)</th>
<th>Direct evidence(^{21}):</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective (Drivers)</td>
<td>Survey (A6)</td>
<td>Explaining the difference between academia and practice: Objectives are very different (profit vs. new knowledge for knowledge sake). (A6, interview)</td>
<td>Goals listed on a design brief</td>
</tr>
<tr>
<td>Brainstorming (Processes [CC])</td>
<td>Interview (A27, A35, A36, P17) and survey (P3, P8)</td>
<td>Explaining his view on design thinking: A design process that originates from the user's POV and grows through brainstorming, collaboration, and prototyping. (P8, survey)</td>
<td>Participants of brainstorming sessions often write down their ideas on paper and describe them using words.</td>
</tr>
<tr>
<td>Mapping (Process [CC])</td>
<td>Interview (P14)</td>
<td>Explaining the meaning of cognition Cognition is about mapping experience of observation in the world, plus thoughtfulness plus perception the what might be comes in. (P14, interview)</td>
<td>A diary written by users to record how they use their products.</td>
</tr>
<tr>
<td>Prototyping (Process [CC])</td>
<td>Interview (A27, A28) and survey (A21, A31, A33, P8)</td>
<td>Creating a service blueprint using words to describe the steps of the journey.</td>
<td></td>
</tr>
<tr>
<td>Qualitative research (Process [CC])</td>
<td>Interview (A27)</td>
<td>User interview and focus groups are examples of qualitative research expressed through language.</td>
<td></td>
</tr>
<tr>
<td>Policy (‘Design problem’, traditional or non-traditional)</td>
<td>Interview (A27, A28, A35, P18, P19, P20) and survey (P1)</td>
<td>An example of a complex problem: So policy is an example of one and the woolly definition I gave with complex stuff would be a definition itself.</td>
<td>White paper for the future of healthcare in the UK</td>
</tr>
</tbody>
</table>

Table 50 Supporting evidence of language

\(^{21}\) Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence(^{22}):</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication design (Multidisciplinary)</td>
<td>Interview (A27, A28, A29, A35)</td>
<td>Explaining how communication design should be taught: I wondered to what extent the teaching staff encouraged their student to do any sort of objective evaluation of the designs, say in communication design you are students to design a piece of information and communication.</td>
<td>Instructions on how to use a piece of software</td>
</tr>
<tr>
<td>Curriculum design (Multidisciplinary)</td>
<td>Interview (A27, A28, A35, A36)</td>
<td>Descriptions of taught modules of an undergraduate course</td>
<td></td>
</tr>
<tr>
<td>Service design (Multidisciplinary)</td>
<td>Interview (A27, A29, A35, P17)</td>
<td>Service touch points such as website and information leaflets.</td>
<td></td>
</tr>
</tbody>
</table>

\(^{22}\) Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
5.5.5.3. Numeracy

Figure 69 An example of numeracy; the unit circle of trigonometry (Mahal, 2013)

Numeracy was the next mode of expression identified from the literature and data. The reason that numeracy was included as a mode of expression was partly due to how design thinking was presented in literature written by practitioners. From the initial literature review, the findings suggested that design thinking provided a competitive advantage to those organisations that applied and embraced it. The way this information was presented was in the form of numbers; such as how Swatch, helped its parent company SMH became a leading watch manufacturer with 14% market share (Verganti, 2009: 73). Other examples from the initial literature review included the Nintendo’s share price increased as a result of strong Wii sales (see Chapter 2.4.5) and using design thinking to speed up F1 pit stop in the 1970s (Cross, 2011: 40-41). From the literature it could be said that numbers was a way of expressing and quantifying the impact of design thinking. Referring back to Baynes’ (2013) work and the previous section written on language; he argued that a designer would use any suitable means of communication to get the job done whether it is through visual media, language or numbers. The following meaning was established for numeracy using the literature evidence: the ability to reason and apply numerical concepts or
communicate using numbers. Tables 52 present the supporting evidence of numeracy identified from the data:
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence\textsuperscript{23}:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget (Drivers)</td>
<td>Interview (P15) and survey (A6)</td>
<td>When discussing the product’s development budget: The development budget for the product was £300,000... (P15, interview)</td>
<td></td>
</tr>
<tr>
<td>Market (Drivers)</td>
<td>Interview (P14, P15) and survey (A8, A16, P4, P7)</td>
<td>Explaining IDEO’s (design consultancy’s) target market: Design thinking for IDEO is a way of getting people to think strategically about their business and their market their customers their product, and product eco systems.</td>
<td>The lower market share of Windows phones compare to others and lower sales figures of a brand due to lack of product range in certain market segment</td>
</tr>
<tr>
<td>Profit (Impact)</td>
<td>Interview (P15, P17, P18, P19, P20) and survey (A6)</td>
<td>Explaining the difference between commercial and academic application of design thinking: (...) commercial is more concern with result and money. There is a bias towards can we sell it, is it viable and can we make it a product? (P17, interview)</td>
<td>$10 million of profit generated from a new product range.</td>
</tr>
<tr>
<td>Value (Impact)</td>
<td>Interview (A36, P15, P17, P18, P19, P20) and survey (A6, A9, A16)</td>
<td></td>
<td>A new product range help increase the value of a brand.</td>
</tr>
</tbody>
</table>

\textsuperscript{23} Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
5.5.5.4. Physicality

During the identification of ‘processes’ another form of expression was identified. It appeared that physical features or 3D forms are also ways to express design thinking. From the literature Esslinger (2009: 7-8) used the early Apple design language that Frog Design created in the 1980s as an example:

‘Apple computers would be small, clean and white.

Final form would offer smart, high tech shapes, created with the most advance tooling.’ (Esslinger, 2009: 8)

Another example of expressing design thinking through physical and 3D forms was provided by Berger (2009: 74):

‘Design researchers are discovering that the very act of tinkering with materials and objects can be an important part of the learning and discovery process.’

Those examples identified from the initial literature review demonstrated design thinking being expressed through those two forms.
In addition to the examples identified in the initial literature review, the mode of expression was related to the regular mentions of prototyping as a process within the literature and data collected. Analysing the way prototyping was presented in literature and the data; it appeared that prototyping was an important aspect of design thinking. Prototyping occurred in many forms; however, a number of examples given from the literature and data were products that were 3D objects such as a hospital bed, bicycles and physical layouts of an airport interior design (see Chapter 2.4.1 and 2.4.6). With many of the prototyping processes or techniques researched and used in design academia and practice today being related to representing objects in 3D and physical forms that cannot be described by language or numeracy. It would make sense to use physicality as a mode of expression. The term physicality had the following meaning: the physical characteristics of an object that can only be expressed in 3D. Tables 53 present the supporting evidence of physicality identified from the data:
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence(^{24}):</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disruptive innovation (Impact)</td>
<td>Interview (P18, P19, P20)</td>
<td>Giving an example of disruptive innovation: Consumers will only tell you what they want and they were looking at doing it the opposite way to disturb it. You know the consumer groups’ notes that Steve Jobs were looking at they were like use this and that and touch the screen I am really scared. And now everyone wants it.</td>
<td>Apple iPod and iPhone and Sony Walkman.</td>
</tr>
<tr>
<td>Products (impact)</td>
<td>Interview (A27, A29, P14, P17) and survey (A2, A4, A7, A8, A18, P2)</td>
<td>An example of a product’s physicality being its feature: Design a chair that fits everybody. (P17, interview)</td>
<td>Design a hearing aid that is smaller in size so that it can be easily hidden.</td>
</tr>
<tr>
<td>Product eco systems (Impact)</td>
<td>Interview (A35, A36, P14, P15, P17) and survey (P3)</td>
<td>An example of a non-traditional design problem from the participant: Designing product service systems of the national post office. (P3, survey)</td>
<td>Apple iPod and iTunes, Sony Play Station and Play Station Network</td>
</tr>
<tr>
<td>Unique selling points [USP] (Impact)</td>
<td>Interview (P18, P19, P20)</td>
<td>A new smartphone being thinner and lighter than its competitors</td>
<td></td>
</tr>
<tr>
<td>Prototyping (Processes [CC])</td>
<td>Interview (A27, A28) and survey (A21, A31, A33, P8)</td>
<td>3D printed splints, paper and foam models used during form development when designing products</td>
<td></td>
</tr>
<tr>
<td>Design context, domain (‘Design problem’, traditional or non-traditional)</td>
<td>Interview (A28, A29, A30, P15, P16, P17, P18, P19, P20) and survey (A7, P2, P5)</td>
<td>An example of a traditional design problem: Traditional design problem, make a chair that fits everybody. It is not possible or it is very hard or it might be possible. (P17, interview)</td>
<td></td>
</tr>
<tr>
<td>Industrial/ product design (Multidisciplinary)</td>
<td>Interview (A29, A30, A35, A36, P14, P15, P17) and survey (A3, P2)</td>
<td>Touch and feel of a product, the size of a product and the form a product</td>
<td></td>
</tr>
</tbody>
</table>

\(^{24}\) Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
5.5.5.5. Processes (ME)

The initial literature review findings suggested that design thinking is being described as a methodology or process of problem solving (Lawson, 1979: 68; Berger, 2009: 302; Cross, 2011: 115-130). From the evidence of the literature review, it could be argued that ‘processes’ are ways of expressing design thinking; as there are steps or strategy that are used when applying design thinking to solve a problem. For example, prototyping as a ‘process’ that was heavily emphasised in literature (Ambrose and Harris, 2010: 22-23; Berger, 2009: 71-95; Brown, 2009: 87-108; Cross, 2011: 94, 101, 123); the heavy emphasis and detail descriptions given on how to prototype showed ‘processes’ are ways to communicate and express design thinking. Another example of ‘processes’ identified from the literature was user centred design (Conran, 2013). Conran (2013) described it as the key to successfully create innovation (see Chapter 2.4.3). These examples suggested ‘processes’ as a way to communicate how design thinking can be applied; therefore, it was logical to see it as a way of expressing design thinking. These were the findings from the initial literature review.

Literature written by academics and practitioners design thinking was often presented as a way of problem solving. This was a theme that occurred throughout the literature reviews. Further evidence was identified through Goldschmidt and Rodgers (2012: 55-72) reporting of the study of design thinking approaches from three different groups of designers. This mode of problem solving was the different processes used at different stages. Examining the findings so far, it could be said that without the different processes design thinking would not occur or move forward towards creating solutions for the problems identified. Therefore with that perspective, it made sense to establish processes as a mode of expression to help understand design thinking. The term process has the following meaning: a series of action directed towards a specific aim. Tables 54-57 present the supporting evidence of processes (ME):
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design for sustainably (Drivers)</td>
<td>Interview (A27)</td>
<td>Users showing designers their processes of a sustainable lifestyle: A community of local residents from New York and designers, where the local residents shared their ways of living sustainably to inspire the designers to design for sustainability. (A27, interview)</td>
<td></td>
</tr>
<tr>
<td>Human/ user centred (Drivers)</td>
<td>Interview (A36, P14, P18, P19, P20) and survey (P7, P8, P11)</td>
<td>Explaining what design thinking is: Design Thinking is an ever evolving bundle of approaches focused on creating a more human centred, life centred world. (P11, survey)</td>
<td></td>
</tr>
<tr>
<td>Creativity (Impact)</td>
<td>Interview (A36, P14) and survey (A7, A19)</td>
<td>Defining his view of what design thinking is: I do feel that in an abstract sense, most uses of the term design end up describing a way of making decisions (usually a way that integrates creative and logical thinking). In particular I see design thinking as the generalization of methodologically making creatively informed decisions, for almost any context.</td>
<td></td>
</tr>
<tr>
<td>Innovation (Impact)</td>
<td>Interview (A27, A28, A36, P14, P18, P19, P20) and survey (A3, A10, A16)</td>
<td>Explaining the commercial perspective on design thinking: Commercial applications see it as an innovation / problem solving method (A16, survey)</td>
<td></td>
</tr>
</tbody>
</table>

Table 54 Supporting evidence of processes (ME)

---

25 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
<table>
<thead>
<tr>
<th>Evidence (Common characteristic)</th>
<th>Evidence source (A: academic; P:practitioner)</th>
<th>Direct evidence26:</th>
<th>Interpretative evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disruptive innovation (Impact)</td>
<td>Interview (P18, P19, P20)</td>
<td>How the iPod was created: I suppose the interesting thing with the Apple example the reason I was looking for it that was a way of using design thinking and the methodology to find out what consumers want. Consumers will only tell you what they want and they were looking at doing it the opposite way to disturb it.</td>
<td></td>
</tr>
<tr>
<td>Social innovation (Impact)</td>
<td>Interview (A27) and survey (P7)</td>
<td>An example of social innovation in New York: So a quick example is that in NYC I was involved in a DESS project so it is a network of researchers concern about design for sustainability and social innovation this particular methodology is that designers don't come up with the good ideas they find good ideas hidden in the community they community has people already innovating sustainable lifestyle.</td>
<td></td>
</tr>
<tr>
<td>Systems (Impact)</td>
<td>Interview (A27, A28, A29, P14, P18, P19, P20) and survey (A18, P4)</td>
<td>What is design thinking: Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem. It is a collaborative and multidisciplinary way of looking at, sketching, and proposing new systems and strategies in business, culture, political systems, health systems and the other organizing frameworks that affect our lives. (P4, survey)</td>
<td></td>
</tr>
</tbody>
</table>

Table 55 Supporting evidence of processes (ME) (Continued from Table 54)

26 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
<table>
<thead>
<tr>
<th><strong>Evidence (Common characteristic)</strong></th>
<th><strong>Evidence source (A: academic; P:practitioner)</strong></th>
<th><strong>Direct evidence27:</strong></th>
<th><strong>Interpretative evidence:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy (Impact)</td>
<td>Interview (A27, A30, A35, P14, P16, P18, P19, P20 and survey (A16, P4))</td>
<td>What is design thinking: An ill-defined hype term for a general method / strategy (A16, survey)</td>
<td></td>
</tr>
<tr>
<td>Unique selling point [USP] (Impact)</td>
<td>Interview (P18, P19, P20)</td>
<td>A new mobile application that made daily organisation easier</td>
<td></td>
</tr>
<tr>
<td>Co-creation (Process [CC])</td>
<td>Interview (A27, P17) and survey (P1)</td>
<td>An example of co-creation: Writing a song in a band is co-creation. (P17, interview)</td>
<td></td>
</tr>
<tr>
<td>Creative processes (Process [CC])</td>
<td>Interview (A35, P16, P17, P18, P19, P20) and survey (A3, A4, P6)</td>
<td>The participant’s view on design thinking: A creative process in human-artefact-environment analysis, design, and evaluation of product, service and/or brand design to ensure successful innovation/entrepreneurship. (A3, survey)</td>
<td></td>
</tr>
<tr>
<td>Empirical research (Process [CC])</td>
<td>Interview (A35, P18, P19, P20)</td>
<td>User interviews, focus groups and Delphi studies</td>
<td></td>
</tr>
<tr>
<td>Human/ user centred design (Process [CC])</td>
<td>Interview (A27, A36, P18, P19, P20) and survey (P7, P12)</td>
<td>The participant’s view on design thinking: A good way of solving wicked problems following a human centred process with frequent feedback from users (P7, survey)</td>
<td></td>
</tr>
<tr>
<td>New product development (Process [CC])</td>
<td>Interview (P18, P19, P20) and survey (A7)</td>
<td>The development of any new products.</td>
<td></td>
</tr>
<tr>
<td>Prototyping (Process [CC])</td>
<td>Interview (A27, A28) and survey (A21, A31, A33, P8)</td>
<td>Create 3D prototypes using CAD then printing the components out via 3D printers. Video prototyping when designing a service.</td>
<td></td>
</tr>
</tbody>
</table>

27 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
<table>
<thead>
<tr>
<th><strong>Evidence (Common characteristic)</strong></th>
<th><strong>Evidence source (A: academic; P:practitioner)</strong></th>
<th><strong>Direct evidence</strong>:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design methods/processes (Process [CC])</td>
<td>Interview (A27, A29, A30, A36, P15, P17, P18, P19, P20) and survey (A7, A8, A9, A15, A21, P4, P5, P7, P8)</td>
<td>Explaining what frame creation is: For me frame creation is one of the core ones, creating new approaches to problems it is something that everybody does, but designers have developed more practices, call them methods if you want to around that to do that.</td>
</tr>
<tr>
<td>Frame creation (Process [CC])</td>
<td>Interview (A35)</td>
<td></td>
</tr>
<tr>
<td>Problem framing (Process [CC])</td>
<td>Interview (A27, A36, P18, P19, P20) and survey (A19, P2, P4)</td>
<td>An example of problem framing: (...) when you hire a designer on a large scale problem that is not define as a traditional design problem; you are having someone who can read the problem in terms of style and technical aspects with networks</td>
</tr>
<tr>
<td>Qualitative research (Process [CC])</td>
<td>Interview (A27)</td>
<td>Interviews, focus groups, Delphi studies</td>
</tr>
<tr>
<td>Design context, domain ('Design problem', traditional or non-traditional)</td>
<td>Interview (A28, A29, A30, P15, P16, P17, P18, P19, P20) and survey (A7, P2, P5)</td>
<td>User centred design, co-design</td>
</tr>
</tbody>
</table>

Table 57 Supporting evidence of processes (ME) (Continued from Table 56)

---

28 Direct evidence: Examples given by the participants. Interpretative evidence: No examples given, interpretations based on literature or personal experience.
5.5.5.6. *How are the common characteristics experts and knowledge expressed?*

The previous sections presented the meaning of the modes of expressions and their supporting evidence; however experts and knowledge were not presented. This was because they were expressed in a different manner. Experts were the people who came from different disciplines who took part in a design thinking project. Therefore experts could interact via any of the modes of expressions identified. Here are a few examples: a design academic who teaches sketching could interact via graphicacy when he demonstrates to the students how to sketch an object in 3D; a social worker could interact via language when interviewed about their area of speciesism to identify insight into an existing social problem; an engineer could be interacted via numeracy and process when showing someone how to conduct FEA analysis on CAD and finally a sculptor could interact with a pottery student via physicality when showing them how to throw a pot. The examples given above also apply to knowledge. For knowledge instead of interaction via a mode of expression; it would be passed on via a mode of expression.
5.5.6. Content analysis findings – is design thinking taught knowingly or unknowingly, of design education?

In order to answer research questions 6 and 7 (see Chapter 5.4.5) content analysis was conducted on the undergraduate taught modules list at the University. Please refer to Appendix 15b for the fully coded modules lists. The content analysis conducted was looking for the following within the modules: the seven common characteristics of design thinking and their modes of expressions. The analysis explored the language used in the module list to determine if design thinking was taught as an integrated aspect knowingly or unknowingly within design education. The outcome of the analysis would also provide some answers towards if there was an advantage in expressing design thinking for someone who had taken formal design education.
From the analysis conducted, the seven common characteristics and modes of expression could be identified from the modules taught at the University. Tables 58-63 provide a summary of the content analysis’ findings:

<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurship and Innovation</td>
<td>Drivers, Impact, Experts, Processes (CC)</td>
<td>Numeracy, Processes (ME)</td>
<td>Numeracy: Funding of SMEs, Processes (ME): Qualitative research</td>
</tr>
<tr>
<td>Design Context</td>
<td>‘Design problem’, traditional or non-traditional, Knowledge, Processes (CC)</td>
<td>Language, Processes (ME)</td>
<td>Language: Express defensible position in verbal or written form Processes (ME): Qualitative research</td>
</tr>
</tbody>
</table>

Table 58 Summary of content analysis conducted on modules taught at Loughborough University
<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics for Design</td>
<td>‘Design problems’ traditional or non-traditional, Knowledge, Processes (CC)</td>
<td>Numeracy, Processes (ME)</td>
<td>Numeracy: Demonstrate knowledge and understanding of mathematical methods used for electronic and circuits systems Processes (ME): Numerical methods to solve basic electrical and electronic engineering problems</td>
</tr>
<tr>
<td>Ergonomics and Design 1</td>
<td>Knowledge, Multidisciplinary</td>
<td>Numeracy</td>
<td>Numeracy: Ability to measure basic aspects of human performance.</td>
</tr>
<tr>
<td>Year 2 Design Practice</td>
<td>Drivers, Knowledge, Processes (CC)</td>
<td>Graphicacy, Physicality, Processes (ME)</td>
<td>Graphicacy: Concept generation, design development and product presentation Physicality: Employ modelling techniques appropriate to industrial design practice Processes (ME): Prototyping, market research and analysis</td>
</tr>
</tbody>
</table>

Table 59 Summary of content analysis conducted on modules taught at Loughborough University (Continued from Table 58)
<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
</table>
| Sustainable Design            | Drivers, ‘Design problems’ traditional or non-traditional, Impact, Multidisciplinary, Knowledge, Processes (CC) | Language, Numeracy, Processes (ME) | Language: Explain the meaning of sustainable design  
Numeracy: Economic issues associated with sustainable design  
Processes (ME): Use sustainable design methods and tools |
| Design Communication          | Knowledge, Processes (CC)                                                                       | Graphicacy, Numeracy, Physicality | Graphicacy: Vector-based and pixel-based graphics presentation techniques  
Numeracy: 3D digital complex curve and surface geometry  
Physicality: 3D digital modelling |
| BSc Design and Manufacturing Technologies | Drivers, ‘Design problems,’ traditional or non-traditional, Knowledge, Processes (CC) | Graphicacy, Physicality, Processes (ME) | Graphicacy: Sketching  
Physicality: Material used for injection moulding, 3D solid CAD modelling  
Processes (ME): Materials selection and manufacturing processes |
| User Experience Design        | Drivers, Impact, Knowledge, Processes (CC)                                                      | Graphicacy, Processes (ME) | Graphicacy: Create user interface design, screen layouts, navigation and usability  
Processes (ME): Prototyping, personas development and usability tests with target users |
| Applications of Electronic Designs | ‘Design problems,’ traditional or non-traditional, Knowledge                                      | Graphicacy, Processes (ME) | Graphicacy: Produce schematics of electronic circuits using standard symbols  
Processes (ME): Design, build and test prototype electronic systems |

Table 60 Summary of content analysis conducted on modules taught at Loughborough University (Continued from Table 59)
<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of Mechanics for Design</td>
<td>‘Design problems,’ traditional or non-traditional, Knowledge</td>
<td>Graphicacy, Processes (ME)</td>
<td>Graphicacy: Manual and computer drugging techniques Processes (ME); Analyse data and performance parameters of mechanical devices</td>
</tr>
<tr>
<td>Universal Design</td>
<td>Drivers, ‘Design problems,’ traditional or non-traditional, Impact, Knowledge, Processes (CC)</td>
<td>Physicality, Processes (ME)</td>
<td>Physicality: Understand the physical and cognitive profiles of target user group Processes (ME); User-centred design processes, new product development</td>
</tr>
<tr>
<td>Computer Aided Ergonomics</td>
<td>Knowledge, Multidisciplinary, Processes (CC)</td>
<td>Physicality, Processes (ME)</td>
<td>Physicality: Understanding of anthropometry, variation of people in size, shape and capability Processes (ME); Virtual ergonomics assessment for existing products</td>
</tr>
<tr>
<td>Dissertation</td>
<td>‘Design problems,’ traditional or non-traditional, Impact, Knowledge, Processes (CC)</td>
<td>Language, Processes (ME)</td>
<td>Language: Present reasoned arguments verbally and in written form Processes (ME): Qualitative research</td>
</tr>
<tr>
<td>User Experience Design</td>
<td>Drivers, Knowledge, Multidisciplinary, Processes (CC)</td>
<td>Graphicacy, Processes (ME)</td>
<td>Graphicacy: Screen based product design and communication Processes (ME); User centred design, interactive product design</td>
</tr>
</tbody>
</table>

Table 61 Summary of content analysis conducted on modules taught at Loughborough University (Continued from Table 60)
<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
</table>
| Final Year Design Practice                 | Drivers, ‘Design problems,’ traditional or non-traditional, Impact, Knowledge, Processes (CC) | Graphicacy, Language, Physicality, Processes (ME) | Graphicacy: Sketching, concept generation  
Language: Produce a design brief  
Physicality: Understanding of human factors and materials  
Processes (ME): Prototyping, new product development, commercial manufacturing processes |
| Materials and Processes for Designers      | Knowledge, Processes (CC)                                     | Physicality, Processes (ME)                      | Physicality: The properties of metals, polymers, ceramics, composites and wood  
Processes (ME): Common processing methods for the materials |
| Foundation Technology (BA route)           | Knowledge, Processes (CC)                                     | Numeracy, Physicality, Processes (ME)            | Numeracy: Mathematical and computer modelling of mechanical systems  
Physicality: Basic materials property  
Processes (ME): Constructing mechanical systems for analysis |
| Industrial Design Studies 1               | Knowledge, Impact, Multidisciplinary, Processes (CC)         | Graphicacy, Physicality                          | Graphicacy: Use drawing and rendering techniques to communicate colour, form and finishes  
Physicality: Justified the physical characteristics of the products |
| Industrial Design Studies 2               | Drivers, Knowledge, Impact, Processes (CC)                   | Graphicacy, Physicality, Processes (ME)          | Graphicacy: Visual articulation of ideas and concepts  
Physicality: Appropriate forms to comply with specific requirements  
Processes (ME): Methodologies for social, user, PEEST and visual research |

Table 62 Summary of content analysis conducted on modules taught at Loughborough University (Continued from Table 61)
<table>
<thead>
<tr>
<th>Module</th>
<th>Common characteristic identified</th>
<th>Modes of expression</th>
<th>Examples of the modes of expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA Design and Manufacturing Technologies</td>
<td>Drivers, ‘Design problems,’ traditional or non-traditional, Knowledge, Processes (CC)</td>
<td>Physicality, Processes (ME)</td>
<td>Physicality: Materials properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Processes (ME): Commercial manufacturing processes</td>
</tr>
<tr>
<td>Physical and Virtual Prototyping in Design</td>
<td>Knowledge and Processes (CC)</td>
<td>Processes (ME)</td>
<td>Processes (ME): CAD modelling for Arduino, design and development for electronic designs using CAD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Language: Communicate design decisions and justification verbally or in written form on presentation boards</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physicality: 3D modelling and rendering of design concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Processes (ME): Qualitative research, user-centred design processes</td>
</tr>
</tbody>
</table>

Table 63 Summary of content analysis conducted on modules taught at Loughborough University (Continued from Table 62)

From the analysis conducted it appeared that design thinking’s seven common characteristics and modes of expression could be identified from the modules taught at the University. The identification of them suggested design thinking is taught as an integrated part within design education. However, to fully answer if design thinking is taught knowingly or unknowingly within design education further content analysis was conducted. From the analysis conducted on the descriptions of the modules; the researcher was able to establish design thinking is taught in an unknowing manner within design education. An example of design thinking being unknowingly taught was Universal Design, a 3rd year optional module. Here is part of the description for the module:

‘To raise the awareness of students to the changing demographic balance of social structures within the UK and Europe, and its effect
on everyday products. To reflect on the efficiency of the methodology used to elicit information from target users and communicate with them to develop a new product design solution based on a user-centred, evidential base approach.

From the description, the common characteristic drivers could be identified from ‘changing demographic balance of social structures within the UK and Europe’. The common characteristic impact could also be identified from ‘develop a new product design solution’ In addition to impact; the mode of expression physicality was also identified from the same statement. However, the common characteristic processes could not be identified as easily as the others unless the reader was looking for it in the following parts: ‘methodology used to elicit information from target users’ and ‘user-centred, evidential based approach’. This is one of the examples identified from the data that suggests design thinking is taught in an unknowingly manner within design education. Tables 64-65 present the summary of the content analysis conducted to answer Research Question 6:

<table>
<thead>
<tr>
<th>Module</th>
<th>Taught knowingly</th>
<th>Taught unknowingly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entrepreneurship and Innovation</strong></td>
<td>CC DVR; EXP; IM</td>
<td>CC PRO</td>
</tr>
<tr>
<td></td>
<td>ME NUM</td>
<td>ME PRO</td>
</tr>
<tr>
<td><strong>Design Practice 1</strong></td>
<td>CC DVR; IM; PRO</td>
<td>CC KE</td>
</tr>
<tr>
<td></td>
<td>ME GRA; PHY; PRO</td>
<td>ME LAN</td>
</tr>
<tr>
<td><strong>Design Practice 2</strong></td>
<td>CC DVR; PRO</td>
<td>CC MP; KE</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>ME GRA; LAN; PHY</td>
</tr>
<tr>
<td><strong>Design Context</strong></td>
<td>CC PRO; KE</td>
<td>ME PRO; LAN</td>
</tr>
<tr>
<td><strong>Computing for Designers 1</strong></td>
<td>CC PRO; KE</td>
<td>CC GRA; PHY</td>
</tr>
<tr>
<td><strong>Electronics for Design</strong></td>
<td>CC PRO; KE</td>
<td>CC TT</td>
</tr>
<tr>
<td></td>
<td>ME NUM; PRO</td>
<td>ME</td>
</tr>
<tr>
<td><strong>Mechanics for Design</strong></td>
<td>CC PRO; KE</td>
<td>CC TT</td>
</tr>
<tr>
<td></td>
<td>ME NUM; PRO</td>
<td>ME</td>
</tr>
<tr>
<td><strong>Ergonomics and Design 1</strong></td>
<td>CC KE</td>
<td>CC MP</td>
</tr>
<tr>
<td></td>
<td>ME NUM; PRO</td>
<td>ME</td>
</tr>
<tr>
<td><strong>Year 2 Design Practice</strong></td>
<td>CC DVR</td>
<td>CC PRO; KE</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>ME GRA; PHY</td>
</tr>
</tbody>
</table>

Table 64 Summary of content analysis findings related to RQ6.
### Key:

**Common Characteristics (CC):**

**Modes of Expressions (ME):**
Graphicacy (GPY) Language (LAN) Numeracy (NUM) Physicality (PHY) Processes (PRO)

<table>
<thead>
<tr>
<th>Module</th>
<th>Taught knowingly</th>
<th>Taught unknowingly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further Electronics for Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>KE PRO</td>
<td>GRA TT LAN</td>
</tr>
<tr>
<td>Further Mechanics for Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>KE PRO</td>
<td>GRA LAN</td>
</tr>
<tr>
<td></td>
<td>NUM PRO</td>
<td>ME LAN</td>
</tr>
<tr>
<td>Sustainable Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO KE</td>
<td>DVR TT MP</td>
</tr>
<tr>
<td>Design Communication</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO</td>
<td>KE</td>
</tr>
<tr>
<td>BSc Design and Manufacturing Technologies</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR PRO</td>
<td>TT KE</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>GRA PHY PRO</td>
</tr>
<tr>
<td>User Experience Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR IM KE PRO</td>
<td>PRO</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>GRA PRO</td>
</tr>
<tr>
<td>Applications of Electronic Designs</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>KE</td>
<td>TT</td>
</tr>
<tr>
<td></td>
<td>ME GRA PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Application of Mechanics for Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>KE</td>
<td>TT</td>
</tr>
<tr>
<td></td>
<td>ME GRA PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Universal Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR TT IM PRO</td>
<td>PRO</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>ME PHY</td>
</tr>
<tr>
<td>Computer Aided Ergonomics</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO MP</td>
<td>CC KE</td>
</tr>
<tr>
<td></td>
<td>ME PHY PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Dissertation</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO</td>
<td>TT</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>LAN PRO</td>
</tr>
<tr>
<td>User Experience Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO KE</td>
<td>CC</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>GRA</td>
</tr>
<tr>
<td>Computer Aided Modelling and Manufacture</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO KE</td>
<td>CC</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>GRA PHY</td>
</tr>
<tr>
<td>Final Year Design Practice</td>
<td>CC</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR PRO TT KE</td>
<td>GRA LAN PHY PRO</td>
</tr>
<tr>
<td>Materials and Processes for Designers</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO KE</td>
<td>CC</td>
</tr>
<tr>
<td></td>
<td>ME PHY PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Foundation Technology (BA route)</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO KE</td>
<td>CC</td>
</tr>
<tr>
<td></td>
<td>ME NUM PHY PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Industrial Design Studies 1</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>IM PRO MP KE</td>
<td>CC GRA PRO</td>
</tr>
<tr>
<td>Industrial Design Studies 2</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO</td>
<td>CC KE</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>GRA PHY</td>
</tr>
<tr>
<td>BA Design and Manufacturing Technologies</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR PRO KE</td>
<td>TT</td>
</tr>
<tr>
<td></td>
<td>ME PHY PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Physical and Virtual Prototyping in Design</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>PRO</td>
<td>CC KE</td>
</tr>
<tr>
<td></td>
<td>ME PRO</td>
<td>ME</td>
</tr>
<tr>
<td>Industrial Design Studies 3</td>
<td>CC ME</td>
<td>CC ME</td>
</tr>
<tr>
<td></td>
<td>DVR IM TT PRO KE</td>
<td>GRA LAN PHY PRO</td>
</tr>
</tbody>
</table>

Table 65 Summary of content analysis findings related to RQ6 (Continued from Table 64)
The tables presented the findings that supported the claim of design thinking being taught in an unknowingly manner within design education.

In addition to answering Research Question 6, the findings from the content analysis also provided the evidence required to answer Research Question 7 (see Chapter 5.4.5).

Using the positions established from the analysis: design thinking is an integrated part of design education that is taught in an unknowingly manner; the logical answer to the research question would be those who have not taken formal design education would be at a disadvantage when it comes to expressing design thinking. The findings suggested that without a formal design education, the following modes of expression could not be expressed sufficiently: graphicacy, physicality and processes (ME). It would be difficult to express them sufficiently because they have very specific ways of being expressed.

An example of graphicacy, physicality and processes (ME) being expressed in a specific way would be creating a visual prototype of a product via CAD modelling and 3D printing. Here, graphicacy would be expressed by the concept sketches generated for the product, the colour combination and virtual CAD models created for prototyping. Physicality would be expressed by the form and size given to the product and finally processes (ME) would be expressed in the form of creating the virtual prototype in CAD and making it a reality via 3D printing. This example showed a combination of methods and steps that are learnt from the undergraduate Product Design course at the University. Without formal design education or training it would be difficult to employ those modes of expression sufficiently. From that viewpoint it appears certain aspects of design thinking (supporting evidences for the common characteristics) would require formal design education to be expressed sufficiently. Table 95 present some examples:
However, the evidence did not suggest *language* and *numeracy* require a formal design education to be expressed sufficiently. It appeared that *language* and *numeracy* are two modes of expression that would not be disadvantaged without formal design education. From this viewpoint, it could be argued that *language* and *numeracy* could be expressed more sufficiently by others such as those with training in languages or mathematics. Using the viewpoint established it appears that certain aspects of design thinking (supporting evidence of the common characteristics) could be expressed without sufficiently formal design education. Table 96 presents some examples:

<table>
<thead>
<tr>
<th><strong>Graphicacy</strong></th>
<th><strong>Physicality</strong></th>
<th><strong>Processes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sketching</td>
<td>Prototyping (foam modelling; 3D modelling)</td>
<td>Universal design</td>
</tr>
<tr>
<td>Brand design</td>
<td>Industrial/ product design</td>
<td>User-centred design</td>
</tr>
<tr>
<td>Communication design</td>
<td>Products</td>
<td>Interaction design</td>
</tr>
<tr>
<td>Graphic design</td>
<td></td>
<td>Co-design</td>
</tr>
</tbody>
</table>

Table 66: Examples of aspects of design thinking that require formal design education to be expressed sufficiently

From the analysis the following conclusion could be established:

- Design thinking is taught as an integrated part of design education.
- Design thinking is taught in an unknowing manner in design education.
- Formal design education is needed in order to express the following modes of expression sufficiently: graphicacy, physicality and processes (ME).
However, formal design education is not needed to express the following modes of expression sufficiently: language and numeracy.

5.6. Summary of Chapter 5

This Chapter presented the data collection methods used, participants of the main study, data analysis methods used and findings from the main study. For the data collection, interviews and online survey were the methods used. 56 participants around the world took part in the study. Within the participants 13 of them took part in interviews and 43 of them took the online survey. The data collected was then analysed by thematic analysis and content analysis. From the thematic analysis the similarities and differences between academic and practitioner viewpoints on design thinking were established; those will be discussed in Chapter 9. Thematic analysis identified the academics and practitioners' key themes of design thinking. The key themes were matched with the existing common characteristics identified from literature review and pilot study and formed basis of their supporting evidence. In addition two additional common characteristics were also identified from those key themes, they were: multidisciplinary and knowledge.

Content analysis was conducted to identify supporting evidence to articulate the common characteristics identified from literature review, pilot study and thematic analysis. Those common characteristics were: drivers, experts, impact, process (CC) and ‘design problems’, traditional or non-traditional, multidisciplinary and knowledge. Content analysis also identified design thinking’s modes of expressions. The modes of expression were: graphicacy, language, numeracy, physicality and process (ME). Finally the content analysis conducted on Loughborough University’s undergraduate taught modules lists showed design thinking was taught as an integrated part of design education in an unknowing manner. The analysis also provided evidence to show those who have not taken a formal design education would be at a disadvantage when expressing the following modes of expressions: graphicacy, physicality and processes (ME). The analysis also established the following modes of expression do not require formal design education to be expressed sufficiently: language and numeracy.
### 5.6.1. Overall progress summary

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where was the concept of design thinking first articulated?</td>
<td>✓</td>
<td>Lit Review (2.2); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do academic and practitioner interpret design thinking differently?</td>
<td>✓</td>
<td>Lit Review (2.3.1 &amp; 2.4); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.2.1, 2.3.1 &amp; 2.5); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td></td>
<td>Lit Review (2.3.1); Interviews and online survey (5.4)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How is design thinking expressed?</td>
<td>✓</td>
<td>Interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 68 Progress summary after Chapter 5
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>6  Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td>✓</td>
<td>Interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7  Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td>✓</td>
<td>Lit Review (2.2.1 &amp; 2.3.1); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8  Does design thinking as incorporated in designing within academia match academic articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9  Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table 69 Progress summary after Chapter 5 (Continued from Table 97)
Chapter 6 - Case study analysis
6.1. Introduction

This Chapter presents six case studies, three from academia; in the form of final year student design projects and three from practice were selected for case study analysis. The case studies from academia were selected from Loughborough Design School’s class of 2013. The decision to select Loughborough only samples was caused by following reasons: time limitation and lack of response from other Universities. As a result of that the decision was made to use internal samples. The Final Year Design Projects at Loughborough had the following aims:

- Integrate and apply knowledge, skills and values from other modules in a significant project over an extended period of two semesters.
- Provide examples of the student’s design and innovation capability for their portfolio and CVs.

The purpose of the case study analysis was to check the reliability of the findings from the main study. As the third aspect of the triangulation, the case study analysis would be looking to see if the seven common characteristics identified from the literature review and data analysis could be identified from the six case studies chosen. Furthermore the case studies analysis would also check the reliability of design thinking’s modes of expressions by matching them to the common characteristics identified in the case studies. All data for the case study analysis were collected from interviews and documents provided by participants.

6.2. Research ethics of the case study analysis

While the participants of the main study (interviews and online survey) conducted the research anonymously (see Chapter 5.3), the case study analysis participants did not. This was because if the case study analysis participants took part anonymously it would have made it impossible to reference them correctly within the thesis. This was explained to the participants prior the start of the case study analysis and they gave their
consent to being named in order to be credited and referenced for their work within the thesis.

6.3. Academic case study I – Trezzex outdoor tracking device

Figure 72 Trezzex tracking device rendering (Amies, 2014)

Project background

The first academic case study was the Trezzex outdoor tracking device, the Final Year Design Project of Jake Amies (2013). Location tracking and social sharing was a relatively new trend, primarily seen in the fitness market, however there weren’t any device that catered to the adventure market as smart phones simply weren’t applicable. The focus was as much on affordability as well as functionality to get the device to as many users as possible. In addition to the newly developed social trend, in recent years there were increased numbers of fatal outdoor adventure accidents caused by delayed emergency responses. This was caused by the lack of communications between the injured and emergency services as well as adventurers not having the proper equipment on themselves. According to the designer the project’s objectives were the following:
• Design a ‘go to’ device for adventurers’ location tracking.

• Provide the location of user when there is an emergency for search and rescue teams.

• The final product must be easy to use and had the ability to be integrated into the user’s social life; for example shared the journeys taken via social media.

• The device must be able to work in any environment.

In order to get the information and knowledge required the designer began by interviewing the target market. For research purposes the designer conducted five interviews with members of the University’s mountaineering club, from the interviews the designer was able to gather the following insight and knowledge: some hikers or adventurers often went away without letting anyone know where they have gone and novice hikers or adventurers tended not carried the suitable equipment with them. In addition to those problems the interviewees also pointed out that some hikers would over estimate their own abilities and therefore increase the chances of accidents by tackling more demanding hikes. After gathering those insights the designer then went on to identify the technology that would enable his device to communicate with emergency services. From his research the designer was able to identify CosPas-Sarsat satellite based distress beacon alert detection and distribution system as a possible low cost solution for his device. He then further investigated into the technology by conducting interviews with a satellite antenna engineer. From the interviews it was established that the technology was a suitable option for his device and it can be easily run on battery power. Once the technology of the device was chosen the designer moved forward to conduct design activities. For the design activities sketching, foam modelling, CAD modelling and 3D printing were the methods chosen to communicate, create and express ideas for a solution. The form of the product was mainly created through sketching and foam modelling as shown in figures 73–75:
Figure 73 Form sketches for Trezzex. (Amies, 2013)

Figure 74 Development sketches of chosen design for Trezzex. (Amies, 2013)
Once the final design of the product was chosen the designer moved forward with product development. During the product development phase the designer built a number of prototypes; these prototypes included a technology test rig, form development models and prototypes of the device’s companion mobile application (shown in Figures 75 and 77). In the interview the designer emphasised that the prototypes were vital to further evolve the final form of the product and test out the use of the technology within the solution created. The technology rig was used for testing out the chosen technology and the companion application. According to the designer the evaluation (shown in Figure 77) went well and he was able to prove the chosen technology worked by locating the participants using the mobile application. Further validation of the solution was conducted via interviews with local emergency services and the University’s Mountaineering Society. In terms of impact the designer claimed that the product can be developed further for manufacturing should the funding become available. In addition to that he also stated the social impact that the product could have; one of the claimed impact was encouraging a safer attitude towards taking part
outdoor activities via creating an online community, another claimed impact was the product could be tapping into a target market that currently did not use the suitable equipment for such activities. Finally the designer claimed that the product could also improve the safety of such outdoor activities.

![Figure 76 Trezzex prototype testing and evaluation. (Amies, 2014)](image)

![Figure 77 Trezzex mobile application screenshots. (Amies, 2014)](image)
**Findings from analysis**

From the case studies the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented in the Tables 70 and 71:

<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>Increased number of outdoor activities related accidents.</td>
<td>Newspaper articles and logbook records</td>
<td>Strong, all were recorded in the designer's logbook</td>
<td>Numeracy</td>
</tr>
<tr>
<td>Experts</td>
<td>Loughborough University Mountaineering Society, Snowboarding Society, Mountain biking team captain and RF antenna technician</td>
<td>Interview records, feedback recorded in logbooks</td>
<td>Strong, all interviews and feedback were recorded in logbook</td>
<td>Interacted via language</td>
</tr>
<tr>
<td>Impact</td>
<td>Prototype proved the technology selected was suitable, positive feedback from experts. Claimed to improve the safety of outdoor activities.</td>
<td>Prototype testing recorded in logbook and expert validation interviews also recorded in logbook</td>
<td>Strong, all prototype tests and expert validation interviews were recorded in logbook</td>
<td>Physicality (prototype product), graphicacy (mobile application)</td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, CAD modelling, prototyping, 3D printing, graphic design, product design and qualitative research methods</td>
<td>Logbook, prototype models, mobile application and portfolio</td>
<td>Strong, all were recorded in logbook and portfolio or shown via physical prototypes</td>
<td>Graphicacy, physicality and processes</td>
</tr>
<tr>
<td>‘Design problem’, traditional or non-traditional</td>
<td>Traditional design problem, an opportunity was identified by designer and he came up with a potential solution</td>
<td>The opportunities were presented in the logbooks</td>
<td>Strong, clearly presented in the logbook</td>
<td>Numeracy, physicality and process (ME)</td>
</tr>
</tbody>
</table>

*Table 70 Evidence of the 7 Common Characteristics and Modes of Expression in academic case study 1*
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary</td>
<td>Graphic design, industrial/ product design, emergency services</td>
<td>Sketches, prototyping processes in logbooks, mobile application, physical prototypes and interview records.</td>
<td>Strong, interviews were recorded in the logbooks, mobile application, sketches and physical prototypes</td>
<td>Graphicacy, physicality and process (ME)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>The chosen location technology, CosPas-Sarsat satellite based distress beacon was selected upon the recommendation of an expert</td>
<td>Interview with expert in logbook and prototype test rig</td>
<td>Strong, presented in logbooks and prototype test rigs</td>
<td>Pass on via language</td>
</tr>
</tbody>
</table>

Table 71 Evidence of the 7 Common Characteristics and Modes of Expression in academic case study 1 (Continued from Table 70)

6.4. Academic case study 2 – Lumo

Figure 78 Lumo (Pendlebury, 2014)
Project background

The second academic case study was the Lumo, the Final Year Design Project of Eleanor Pendlebury (2013). Lumo shown in Figure 78 was a product designed to provide comfort and reassurance to children with separated/divorced parents; focusing on a disrupted night time routine due to the child living between two homes (Pendlebury, 2013). The number of divorced families in the UK had increased sharply since the 1960s; in 2011 the number of divorced families in the UK was 117,000. Up to 49% of those divorced families had children under the age of 16 and within that figure 21% of those children were under the age of five. According to the designer the project had the following objectives:

- Provide comfort and reassurance to the child.
- Help the child to settle in new and unfamiliar environments.
- Minimise the disruption in the child’s night time route caused by switching environments.

In order to get the information and knowledge required to generate suitable solutions towards the problems identified the designer conducted interviews with experts in the related field. The experts selected by the designer were social workers and children counsellors. From the interviews the designer was able to identify a key insight regarding the problem; the objects that belonged to the children became their security. In addition to providing the key insight the experts also helped to shape a questionnaire used by the designer to gather further data during the research phrase of the project. The data gathered via the questionnaire was used to shape the specification and features of the design. With the specification and features requirements set the project moved forward towards the design phrase. During this phrase sketching, foam models, CAD modelling and 3D printed models were the selected forms of communication. The form of the product was created through sketching and CAD modelling as shown in figures 79-81:
Figure 79 Design sketches of Lumo (Pendlebury, 2013)

Figure 80 Sketch of Lumo's final design (Pendlebury, 2013)
From the design phase the following solution was created by the designer: Lumo would be a product that helped children to minimise the disruption towards their night time routine caused by switching between their places of living. The proposed solution would contain a pair of the same devices therefore allowing the children to have them at their parents’ residences. The link between the devices would be a portable USB recorder that could be plugged into the devices. With the blueprint of the solution laid out the designer then moved onto creating the form of the product and prototyping. The form of the product was developed by sketching and CAD modelling. Once the form of the product was finalised the designer moved forward to creating working prototypes by using CAD modelling and 3D printing. The prototypes created were then used for user validation and testing, Figures 82-84 showed the prototypes being built and the evaluation conducted:
For the evaluation the designer had the following areas tested:

- Lamp light and projection
- USB device functionality
- Aesthetic of the USB

In addition to those the evaluation also gathered the opinions of experts. According to the designer some improvements towards the product were identified from the evaluation. Those areas were: the touch and feel of the light switches, feedback regarding light dimming levels and control layout. The experts’ opinions were positive overall, however they were concerned about the potential price range of the product if it were to be manufactured and they also pointed out further market research would be needed. In terms of impact when interviewed the designer believed it could help towards
children from divorced families by providing them a familiar object to relate to in an alien environment.

**Findings from the analysis**

From the case study the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented in the Tables 72 and 73:

<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>A sharp increase in divorce cases since the 1960s.</td>
<td>National statistics figures presented in logbooks</td>
<td>Strong, recorded and presented in logbooks</td>
<td>Numeracy</td>
</tr>
<tr>
<td>Experts</td>
<td>Six social workers, specialised in counselling children in divorced families</td>
<td>Interviews</td>
<td>Strong, all interviews were recorded and presented in the logbook</td>
<td>Interacted via language</td>
</tr>
<tr>
<td>Impact</td>
<td>Prototype of the product created, tested and validated by experts</td>
<td>Prototype and storybooks</td>
<td>Strong, all prototypes were presented during the interview with the designer.</td>
<td>Graphicacy and physicality</td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, CAD modelling, prototyping, 3D printing, graphic design, product design and qualitative research methods</td>
<td>Logbooks and prototype models</td>
<td>Strong, all were recorded in logbook and portfolio or shown via physical prototypes</td>
<td>Graphicacy, physicality and process (ME)</td>
</tr>
<tr>
<td>‘Design problem’, traditional or non-traditional</td>
<td>A non-traditional design problem, the number of divorced families in the UK that had children under the age of five.</td>
<td>Interview with the designer herself and information from logbooks</td>
<td>Weak, despite the context the information in the logbooks presented, the designer could not be certain if it was a non-traditional design problem when interviewed</td>
<td>Numeracy</td>
</tr>
</tbody>
</table>

Table 72 Evidence of the 7 Common Characteristics and Modes of Expression in academic case study 2
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary</td>
<td>Graphic design, industrial/product design and social services</td>
<td>Sketches, prototyping processes in logbooks, mobile application, physical prototypes and interview records</td>
<td>Strong, presented in logbooks and prototypes.</td>
<td>Graphicacy, language, physicality and process (ME)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>The objects owned by the children become their security; the objects helped them to settle in new environments.</td>
<td>From interviews</td>
<td>Strong, the interviews were recorded in logbooks</td>
<td>Passed on via language</td>
</tr>
</tbody>
</table>

Table 73 Evidence of the 7 Common Characteristics and Modes of Expression in academic case study 2 (Continued from Table 72)

6.5. Academic case study 3 – Mom inflatable incubator

![The Mom inflatable incubator](image)

**Project Background**

The final academic case study was the Mom, inflatable incubator; it was the Final Year Design Project of James Roberts. The Mom inflatable incubator (shown in Figure 85) was designed to be a low cost portable incubator that could be used in field hospitals and refugee camps (Roberts, 2013). According to data provided by the designer 1000 out of 100000 children born in refugee camps were born prematurely. Furthermore it was estimated
that in refugee camps 75% of premature child deaths were caused by the lack of incubation. The issue identified by the designer was that traditional incubators were too expensive (a unit can cost from £10000 to £30000) and bulky for developing countries, therefore a smaller more affordable incubator was needed. Another additional problem spotted by the designer was the lack of experienced doctors working in refugee camps and rural areas; as a result the medical care in those areas was often provided by clinical workers. This was problematic because the traditional incubators were too difficult to operate due to its complexity. For research the designer conducted interviews with paediatrics specialist doctors from Nottingham Hospital and experts within the University. In addition to that the designer also conducted online questionnaires with nurses and midwives. From the research the key knowledge or insight identified was that keeping the children’s bodies above a certain temperature was key to survival. With that knowledge in mind the designer then began the design process to generate the solution. During the design phrase the designer used sketching, CAD modelling, foam modelling and prototyping to create and developed the solution as shown in figures 86 and 87:

Figure 86 Concept and development sketches of Mom inflatable incubator (Roberts, 2013)
Once the designer finalised the design of the solution, he began building prototypes to test the technology selected for the solution. From the testing it
was proven that the selected technologies were suitable for the solution the designer then move forward to creating a presentation model of the solution. For validation the technology prototype went through a series of tests to ensure the technologies could maintain its performance consistently throughout a set time period. In addition to running further tests on the prototype, the design was also evaluated by the experts who participated in the research phrase of the project. Figures 90-91 show some of the tests conducted:

![Fan and temperature testing](image1.png)

**Figure 90 Fan and temperature testing (Roberts, 2014)**

![Outer limiter sensors testing](image2.png)

**Figure 91 Outer limiter sensors testing (Roberts, 2014)**
From the testing and evaluation the designer was able to identify the following areas of improvement: a change of material for the zippers to minimise the risk of contamination, addition ventilation points within the main chamber and finally the most important area of improvement was to change the ribbing design of the product to improve its performance of maintaining temperature. Alongside the functionality evaluation of the product a manufacturing feasibility study was also conducted. From the report presented by the designer the manufacturing cost per unit was £86.01 and the intended RRP was £250 per unit. The RRP was £65 cheaper than its nearest competitor. In terms of impact this design project was the winner of the James Dyson Award in 2014. As a result of that the designer began further development of product and with the goal bringing the product to the market in the near future.

Findings from the analysis

From the case study the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented in Table 74:
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>1000 out of 100000 children born in refugee camps are premature babies.</td>
<td>Data presented by the designer in the logbooks</td>
<td>Strong, evidence presented in logbooks</td>
<td>Numeracy</td>
</tr>
<tr>
<td>Experts</td>
<td>Two paediatrics specialist doctors from Nottingham Hospital plus nurses and midwives.</td>
<td>Interviews conducted by the designer during the research phrase, plus the online questionnaire</td>
<td>Strong, all interviews and the online questionnaire used were presented in the logbooks.</td>
<td>Interacted via language</td>
</tr>
<tr>
<td>Impact</td>
<td>Prototype, James Dyson Award 2014</td>
<td>Prototypes constructed and press releases from the University and James Dyson Foundation website</td>
<td>Strong, prototypes were presented and press releases can be found online.</td>
<td>Physicality and numeracy</td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, CAD modelling, prototyping, qualitative research and 3D printing</td>
<td>Logbooks and prototype models</td>
<td>Strong, all sketches, interviews, questionnaire used were presented in logbooks and prototype models.</td>
<td>Graphicacy, language, physicality and process (CC)</td>
</tr>
<tr>
<td>'Design problems', traditional or non-traditional</td>
<td>Traditional design problem, a problem was identified and the designer generated a suitable solution that is less expensive than existing products.</td>
<td>Cost analysis presented in logbook and prototype models</td>
<td>Strong, cost analysis process was presented in the logbooks and reports alongside prototype models.</td>
<td>Physicality and numeracy</td>
</tr>
<tr>
<td>Multidisciplinary</td>
<td>Industrial/ product design and healthcare</td>
<td>Expert interviews, sketching, prototypes and processes presented in logbooks and prototype models.</td>
<td>Strong, all were presented in logbooks or prototypes</td>
<td>Graphicacy, language, physicality and process</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Keeping a constant body temperature was key to the survival of premature babies</td>
<td>From interview conducted with experts</td>
<td>Strong, the knowledge was highlighted in the interviews presented in the logbooks.</td>
<td>Passed on via language</td>
</tr>
</tbody>
</table>

Table 74 Evidence of the 7 Common Characteristics and Modes of Expressions in academic case study 3
6.6. Practice case study 1 – ASAP Watercrafts

Project background

The first practice case study was the ASAP Watercraft. ASAP Watercraft is an electric power assisted watercraft for beach lifeguards that is a cheaper alternative to a jet ski. It could be operated by one person only for rescue or patrol operations. In addition, the craft could be solar charged (ASAP Watercrafts, 2014). The project began as the Final Year Design Project of Ross Kemp, the designer and founder of ASAP Watercrafts. The aim of the project was to develop a watercraft that could bridge the gap between paddle boards and jet skis in terms of performances and deployment time. During the project, Kemp designed and developed a prototype watercraft as the figure below showed some of the original development CAD and sketches:
Eventually the ASAP Watercrafts became Kemp’s full time job. In the first phrase of the redevelopment of product he used sketching, foam modelling, CAD modelling and 3D printing to further resolve and develop the design. The figures below showed an early prototype created from the first phrase of the redevelopment:

The prototype shown in the figure above was used for water testing and further refinement of the propulsion systems as well as marketing. According to the designer, the early prototype was an extremely effective marketing tool in terms of helping him attracting further funding and recruiting additional experts on to the design team. With further funding and a larger
design team the project moved forward into redesign and developing the product for manufacturing. The team that took part in this phrase were the designer, a mechanical engineer whose expertise was in electric power trains and drive trains design, an electrical engineer, a financial manager provided by one of his sponsors, Loughborough Enterprise Studio manager and his investor who deals with funding and marketing. During this phrase the product was redesigned to its current form as shown below:

Figure 95 Rescue Hero prototype (ASAP Watercrafts, 2014d)

The new design was created by the designer along with the help of the mechanical engineer and electrical engineer. As a result of the help and advice from the engineers the new design is smaller than the earlier prototype. Furthermore the designer also stated the redesigned watercraft is lighter and easier to transport than the previous version. With the help of his sponsors the designer was able to fly out to Australia to conduct further tests and evaluation of the new design. When asked what impact would the product have the designer listed the following: a lighter and fast deploy water craft for beach rescue crews with a performance advantage over existing equipment, price advantage over a jet ski, saving lives and great marketing for the University. The product is currently in pre-production development; according to the company’s website production should begin in 2015.
Findings from the analysis

From the case study the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented in Tables 75 and 76:

Figure 96 Recuse Hero prototype testing in Australia (ASAP Watercrafts, 2014e)
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>Peddle boards are too slow in terms of speed. Jet skis took too long to deploy and expensive to purchase.</td>
<td>Interview with the designer</td>
<td>Strong, presented in designer’s notebook during interview</td>
<td>Numeracy and physicality</td>
</tr>
<tr>
<td>Experts</td>
<td>Mechanical engineer, electronic engineer, financial manager, studio manager and marketing expert</td>
<td>Interview with designer, University press releases and company website</td>
<td>Strong, the designer presented press photos</td>
<td>Interacted via language, numeracy and physicality</td>
</tr>
<tr>
<td>Impact</td>
<td>A number of prototypes, university marketing materials, company website, media coverage</td>
<td>Prototypes, marketing material of Loughborough University, magazine articles and company website</td>
<td>Strong, prototypes, university marketing materials, magazine articles were all presented and made available by the designer</td>
<td>Graphicacy, numeracy, physicality and process</td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, CAD modelling, 3D printing, prototyping, qualitative research</td>
<td>Interview with the designer</td>
<td>Weak, only a selective amount of processes could be shown by the designer during the interview. The processes shown were sketching, some CAD modelling and prototyping. Qualitative research methods were used according to the designer but no evidence was presented.</td>
<td>Graphicacy, language, physicality and process (ME)</td>
</tr>
</tbody>
</table>

Table 75 Evidence of the 7 Common Characteristics and Modes of Expressions in practice case study 1
<table>
<thead>
<tr>
<th><strong>Common Characteristics</strong></th>
<th><strong>Evidence</strong></th>
<th><strong>Evidence sources</strong></th>
<th><strong>Evidence strength</strong></th>
<th><strong>Modes of expressions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Design problem’, traditional or non-traditional</td>
<td>Traditional design problem, there was a clear performance gap between existing equipment</td>
<td>Interview with the designer</td>
<td>Strong, the designer believed it was a traditional design problem, the evidence provided also pointed toward that</td>
<td>Numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Multidisciplinary</td>
<td>Industrial/product design, mechanical engineering, electronic engineering and marketing</td>
<td>Interview with the designer, prototypes, marketing materials from the University and company website</td>
<td>Strong, the designer clearly stated these disciplines during the interview and additional information was provided from the marketing materials and company website</td>
<td>Graphicacy, numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Lifeguards interviewed by the designer identified the performance gaps with the existing equipment, engineering solutions of the prototype’s power train and wiring.</td>
<td>Interview with the designer</td>
<td>Strong, the designer stated the knowledge he used and gain during the design phrase</td>
<td>Passed on via language and numeracy</td>
</tr>
</tbody>
</table>

Table 76 Evidence of the 7 Common Characteristics and Modes of Expressions in practice case study 1 (Continued from Table 75)
6.7. Practice case study 2 – Service Design Jam, Loughborough, March 2014

Workshop background

The Service Design Jam Loughborough was a service design workshop that was part of the Global Service Design Jam which took place at cities around the world annually since 2011. The aim of the workshop was to teach the participants service design methods and techniques to create potential service solutions from a brief that was given by the organisers. Before the brief was given, the participants were encouraged to network and get into groups with others who had similar areas of interest. For the Loughborough workshop the participants were split into six teams of six according to their areas of interest and once the teams were created they were each given a mentor. The participants who took part in the 2014 workshop were students from the University, local business owners and academics. The mentors were academics and practitioners invited by the event’s local organiser. For the Loughborough workshop the mentors’ team was three design academics and three experienced service designers. The roles of the mentors were the following: provide guidance on service design method and techniques and keep the teams on track towards the objectives set by the teams themselves. In addition to inviting mentors the local organiser also had to provide all the prototyping materials needed. Once the teams had their mentors assigned the brief was given live on video by the global organisers. Once the brief was given the team had a weekend to generate a service solution. Throughout the weekend there were progression checkpoints. At the end of Friday evening, teams needed to present their team names and an outline their concept of the solution. In the early afternoon of the Saturday the teams gave a ten minutes presentation on their progress and when possible demonstrate their solutions. Finally on Sunday afternoon the teams would each give a twenty minutes presentation presenting their solutions towards the given brief.

For the 2014 Loughborough Service Jam, the brief given was an empty box as shown in Figure 97:
With the brief given the teams moved forward to create their solutions. For this brief the Loughborough participants came up with a range of different concepts. The solution concepts were: a box containing information, coupons and a student contact for international students joining a new University, an online shop selling antique toys, a box for disasters relief, an outdoor culture event centred around a box (container) and an interactive box that encourage children to take part in outdoor activities. Below were some of the images taken from the workshop of the different teams’ design:
Figure 98 Team 3D Life service flow diagram
Figure 99 Team Buddy in a Box service concept
Figure 100 Team Bx's service flow diagram
Figure 101 Team Craveculture.com service stakeholder diagram
Figure 102 Team Kokoro Box's customer journey mapping diagram
Figure 103 Team Outside In smartphone application wireframes
When it came to designing the service solutions the teams used the following methods and techniques: for data gathering all the teams conducted interviews, for creating the service solutions the teams used sketching, prototyping, mapping, role playing and user centred design. During the design phase prototyping was heavily emphasised by the mentors to the groups as an important part of the design process. The groups were encouraged to use the following the prototyping techniques: paper prototyping; this technique were used for setting out the service touch points and order, physical prototyping created the props use for role playing and presentations. Finally video prototyping were also encouraged by the mentors. In addition to prototyping role playing was also a technique used heavily during the design phrase. This technique was used regularly to help the teams understand how their proposal solution would work, where and what service touch points would be needed, interaction between user and the service as well as understanding the users’ viewpoint.

**Findings from the analysis**

From the case studies the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented in Table 77:
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experts</td>
<td>Three interaction designer academics and three service designers</td>
<td>The experts themselves</td>
<td>Strong, the experts took part in the workshop</td>
<td>Interacted via graphicacy, language, physicality and process (ME)</td>
</tr>
<tr>
<td>Impact</td>
<td>Arguably none as all the service created were only concepts within a workshop environment</td>
<td>Service design concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, prototyping, qualitative research, mapping and role playing</td>
<td>Prototypes, concept illustrations, presentations, videos created by the participants</td>
<td>Strong, the teams kept detail records of all their work and processes used through the workshop, some of the materials were uploaded on to the global website.</td>
<td></td>
</tr>
<tr>
<td>‘Design problem’, traditional or non-traditional</td>
<td>A non-traditional design problem because the workshop is open to anybody who wish to learn and take part in service design</td>
<td>Interview with the local organisers and global website.</td>
<td>Strong, the goal of the workshop was clearly stated by the organisers when interviewed and the global website also stated the workshop goals.</td>
<td></td>
</tr>
<tr>
<td>Multidisciplinary</td>
<td>Service design, interaction design and industrial/product design</td>
<td>Participants and mentor backgrounds</td>
<td>Strong, information provided by all who took part in the workshop</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Service design techniques, prototyping methods and design research methods</td>
<td>From the final presentations created by the teams and interview with mentors</td>
<td>Strong, the mentors were able to list the methods used by each team.</td>
<td>Passed on via graphicacy, language and process (ME)</td>
</tr>
</tbody>
</table>

Table 77 Evidence of the 7 Common Characteristics and Modes of Expressions in practice case study 2
6.8. Practice case study 3 – Black and Decker garden power tools range

![Image of Black+Decker 36V lithium battery platform](image)

**Figure 104** The Black+Decker 36V lithium battery platform (Stratford, 2014)

**Project background**

The final practice case study was the Black+Decker garden power tools range launched in 2011 (shown in Figure 104 and 105). The case study was provided by Mark Stratford who led the in house design team that created the European lawnmower platform and other DIY power tools for the brand. From the interview the designer listed the following factors as the drivers that kick started the project: Black+Decker was not a major player in the home DIY tools market due to the lack of power garden tools; in order to increase sale revenue and have bigger presence in retail stores a power garden tools range was required and finally the brand needed to attract more customers. The project began with the design team conducting market research using qualitative research methods. For market research the design team conducted consumer focus groups, in depth interviews with target users and observations. From the research the design team was able to identify these areas of improvement: when mowing the lawn it was very hard to get the edge cut neatly, throwing away the cut grass was an issue for some users and lengthy cable made electric powered mowers harder to use. These were the three areas that the team focused on when designing the
new product range. The design phrase began straight after market research. According to the designer, the concept design phrase took nearly a year to complete. It took the team nearly a year to conduct the testing, prototyping, resolving engineering issues and development for manufacturing of the selected design concept. Prototypes were created by 3D printing and hand built in workshops. Finally because it was a brand new product range it took the company nine months to get the tooling ready for manufacturing. During the interview the designer highlighted the following innovative features and USP of the lawn mower range: Edge Max; a patent technology that ensure the user has a neatly cut lawn edge, high performance anti stall cutting system for cutting tall and damp grass, quick release cable storage and a large grass box. The figure below shows one of the current lawn mowers on sale from Black+Decker:

![Figure 105 Black+Decker 40V Max Mower (Black+Decker, 2013)](image)

Despite the USPs and some of the innovative features the designer also stated the product had a slow start due to delays in production and some engineering issues within the design. After the launch of the lawnmower range the design team moved forward using the design language created for the lawn mower range to create additional products for the power garden
tools range, the figures below showed portfolio pages provided by the designer of the power tools design language:

Figure 106 Design language of the Black+Decker tools (Stratford, 2014)

Figure 107 Design language of the Black+Decker tools (Stratford, 2014)
When questioned about the impact of the project, the designer listed the following: despite having a slow start in sales the new range had generated more than $10 million in business growth for the brand, new patented technology features for the brand and helped the brand to have a bigger retail presence and attract new customers to the brand.

*Findings from the analysis*

From the case studies the following evidence for the seven common characteristics and modes of expressions was identified, the evidence is presented Table 78:
<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Evidence</th>
<th>Evidence sources</th>
<th>Evidence strength</th>
<th>Modes of expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>Lack of power garden tools within the brand, need of attracting customers and expanding presence in retail</td>
<td>Interview with designer</td>
<td>Strong, the designer provided a detail analysis that the team conducted during the interview</td>
<td>Numeracy</td>
</tr>
<tr>
<td>Experts</td>
<td>The design team, mechanical engineers, electronics engineers, tooling engineer and production engineers</td>
<td>Interview with the designer</td>
<td>Strong, the designer was able to list all those who took part in the project during the interview</td>
<td>Interacted via graphicacy, numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Impact</td>
<td>$10 million in business growth, new brand language for products, patented technology</td>
<td>Interview with the designer, products on sale and retail stores</td>
<td>Strong, shown in products and examples given by the designer during the interview</td>
<td>Graphicacy, numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Processes (CC)</td>
<td>Sketching, CAD modelling, 3D printing, mechanical engineering, electronics engineering, new product development</td>
<td>Interview with the designer</td>
<td>Weak, the designer was able to speak briefly about the processes used however he could not give out too much detail due to confidentiality agreements</td>
<td>Graphicacy, numeracy, physicality, process (ME)</td>
</tr>
<tr>
<td>‘Design problem’, traditional or non-traditional</td>
<td>A traditional design problem, a range of products created to fill the gap in a brand’s line up</td>
<td>Interview with the designer</td>
<td>Strong, the designer stated he believed it was a traditional design problem</td>
<td>Graphicacy, numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Multidisciplinary</td>
<td>Industrial/ product design, mechanical engineering and electronic engineering</td>
<td>Interview with the designer</td>
<td>Strong, he listed the disciplines involved during the interview</td>
<td>Graphicacy, numeracy, physicality and process (ME)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Cutting a near edge was an issue, emptying grass was more time consuming than most users anticipate and the long cable makes the mowers hard to use.</td>
<td>Interview with the designer</td>
<td>Strong, the designer was able to list them during the interview and identified them as the knowledge used to create the USPs.</td>
<td>Passed on via graphicacy, language and process (ME)</td>
</tr>
</tbody>
</table>

Table 78 Evidence of the 7 Common Characteristics and Modes of Expressions in practice case study 3 (Continued from Table 110)
6.9. Findings and conclusions from the case study analysis

6.9.1. Data driven consensus definition of design thinking

Two consensus definitions of design thinking were developed from the findings of thematic analysis and content analysis. This section of the chapter presents and discusses the two definitions created. The next section of the chapter presents the reliability checks performed on the definitions though case study analysis. These two consensus definitions will be used to form the basis of the qualitative data driven model of design thinking which will be presented and discussed in Chapter 7 of this thesis.

As presented in Chapter 5.4.2 there were similarities and differences between academic and practitioner’s views on design thinking. The two consensus definitions were developed from the key themes identified.

From the academic perspective design thinking was:

A designerly approach to problem solving that can be used divergently to solve problems in any context and create solutions by using suitable expertise and knowledge.

Table 81 presents the words used in the definition and the related key themes.

<table>
<thead>
<tr>
<th>Words used</th>
<th>Related key themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A designerly approach to problem solving</td>
<td>design/ design processes/ design methodology ‘and problem solving</td>
</tr>
<tr>
<td>Used divergently</td>
<td>Divergent</td>
</tr>
<tr>
<td>To solve problem in any context and create solutions</td>
<td>Problem solving, complex or wicked problems and problem context/ outside design</td>
</tr>
<tr>
<td>Using suitable expertise and knowledge</td>
<td>Experts or multidisciplinary, creative thinking/ creativity and users</td>
</tr>
</tbody>
</table>

Table 79 Breakdown of the empirical data driven academic definition of design thinking

329
From the practice perspective design thinking was:

A collection of human centred design-led problem solving processes or approaches that address ill-defined problems in any context or discipline creatively by focused questioning.

Table 82 presents the words used in the definition and the related key themes.

<table>
<thead>
<tr>
<th>Words used</th>
<th>Related key themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human centred design-led problem solving processes or approaches</td>
<td>Human centred/user centred, design processes/design-led mind set and approaches and problem solving</td>
</tr>
<tr>
<td>Address ill-defined problems</td>
<td>Complex or wicked problems</td>
</tr>
<tr>
<td>In any context or discipline creativity</td>
<td>Multidisciplinary, outside design and creative/creativity</td>
</tr>
<tr>
<td>Asking the right questions</td>
<td>Questions</td>
</tr>
</tbody>
</table>

To summarise the key difference between the two definitions mainly lay within the context in which academic and practice saw design thinking being applied. From the academic viewpoint design thinking could be used anywhere as long as the suitable expertise and knowledge could be included. From the academic viewpoint many of the ‘marketing emphasises’ from the practice point of view were seen as logical components required. For example the practice data set showed claims that employing design thinking could help those employing it engage with users and made them becoming more empathic, however in the academic view this is all part of the necessary requirement to create solutions from using design thinking. Another example of difference would be the view on creativity, practitioners see it as an impact but academics saw it as a requirement. Furthermore there were also differences in the way of framing the problems given. In practice it was very clear that questioning is a problem framing technique however from the academic perspective the problem framing technique was not mentioned. Despite their differences both parties agreed that design thinking is the use of design processes to solve complex or wicked problems in any given problem contexts.
6.9.2. Checking the reliability of the consensus definition of design thinking

In addition to ensuring the reliability of the 7 common characteristics of design thinking and design thinking’s modes of expressions; the data driven consensus definitions of design thinking were also checked by case study analysis.

To check the reliability of the consensus definition via case study analysis the definitions were split into four parts as shown in Table 83:

<table>
<thead>
<tr>
<th>Academic consensus definition</th>
<th>Practitioner consensus definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A designerly approach to problem solving</td>
<td>Human centred design-led problem solving processes or approaches</td>
</tr>
<tr>
<td>Used divergently</td>
<td>Address ill-defined problems</td>
</tr>
<tr>
<td>To solve problem in any context and create solutions</td>
<td>In any context or discipline creativity</td>
</tr>
<tr>
<td>Using suitable expertise and knowledge</td>
<td>Asking the right questions</td>
</tr>
</tbody>
</table>

Table 81 Splitting the consensus definitions

Tables 83-89 present the evidence supporting the two consensus definitions.

Evidence of the academic consensus definition from academic case studies:

<table>
<thead>
<tr>
<th>Case study/evidence</th>
<th>A designerly approach to problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic case study 1 – Trezzex location device</td>
<td>Sketching, CAD modelling, prototyping, 3D printing, interviews and questionnaires</td>
</tr>
<tr>
<td>Academic case study 2 – Lumo</td>
<td>Sketching, CAD modelling, prototyping, 3D printing, interviews and questionnaires</td>
</tr>
<tr>
<td>Academic case study 3 – Mom inflatable incubator</td>
<td>Sketching, CAD modelling, prototyping, 3D printing, interviews and questionnaires</td>
</tr>
</tbody>
</table>

Table 82 Evidence from the academic case studies to support ‘a designerly approach to problem solving’.

<table>
<thead>
<tr>
<th>Case study/evidence</th>
<th>Used divergently</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic case study 1 – Trezzex location device</td>
<td>Created a low cost outdoor tracking device with integrated social media sharing as an additional safety feature</td>
</tr>
<tr>
<td>Academic case study 2 – Lumo</td>
<td>The product integrated functions and features that were inspired by those elements.</td>
</tr>
<tr>
<td>Academic case study 3 – Mom inflatable incubator</td>
<td>Create a low cost mobile incubator using existing technologies.</td>
</tr>
</tbody>
</table>

Table 83 Evidence from the academic case studies to support ‘used divergently’.
Case study/evidence | To solve problem in any context and create solutions
---|---
Academic case study 1 – Trezzex location device | Emergency services, industrial/ product design and outdoor activities
Academic case study 2 – Lumo | Industrial/ product design and social services
Academic case study 3 – Mom inflatable incubator | Healthcare, industrial/ product design and social services

Table 84 Evidence from the academic case studies to support ‘to solve problem in any context and create solutions’.

Case study/evidence | Using suitable expertise and knowledge
---|---
Academic case study 1 – Trezzex location device | Identified the suitable tracking technologies via interview with a RF antenna technician. Insights on target market behaviour provided by interviews with the University’s outdoor activities clubs (Mountaineering and mountain biking).
Academic case study 2 – Lumo | Using knowledge gathered from experts (social workers) the designer identified the elements (familiar objects and parents’ presence) that help a child settle in new environments.
Academic case study 3 – Mom inflatable incubator | With the help of experts: 2 paediatrics specialist doctors from Nottingham Hospital plus nurses and midwives. The most important functions were identified and created a low cost incubator for developing countries by combining existing technologies.

Table 85 Evidence from the academic case studies to support ‘using suitable expertise and knowledge’.

Evidence of the practitioner consensus definition from practice case studies:

Case study/evidence | Human centred design-led problem solving processes or approaches
---|---
Practice case study 1 – ASAP Watercrafts | Sketching, CAD modelling, prototyping, 3D printing, interviews, observations, mechanical engineering and electronic engineering
Practice case study 2 – Loughborough Service Design Jam 2014 | Mapping, interviews, prototyping and service design
Practice case study 3 – Black+Decker garden power tools range | Sketching, CAD modelling, prototyping, 3D printing, interviews, observations, mechanical engineering, electronic engineering and branding

Table 86 Evidence from the practice case studies to support ‘human centred design-led problem solving processes or approaches’.
### Case study/evidence

<table>
<thead>
<tr>
<th>Case study/evidence</th>
<th>Address ill-defined problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice case study 1 – ASAP Watercrafts</td>
<td>A lighter and easily deployed watercraft for beach rescue position in between pedal boards and jet skis.</td>
</tr>
<tr>
<td>Practice case study 2 – Loughborough Service Design Jam 2014</td>
<td>Teaching service design to non-designers</td>
</tr>
<tr>
<td>Practice case study 3 – Black+Decker garden power tools range</td>
<td>Create a new design language for the brand. Using the new design language to create a new range of power tool.</td>
</tr>
</tbody>
</table>

Table 87 Evidence from the practice case studies to support ‘address ill-defined problems’.

<table>
<thead>
<tr>
<th>Case study/evidence</th>
<th>In any context or discipline creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice case study 1 – ASAP Watercrafts</td>
<td>Emergency services, industrial/ product design and vehicle engineering</td>
</tr>
<tr>
<td>Practice case study 2 – Loughborough Service Design Jam 2014</td>
<td>Service design workshop</td>
</tr>
<tr>
<td>Practice case study 3 – Black+Decker garden power tools range</td>
<td>Branding, industrial design/ product design, engineering and marketing</td>
</tr>
</tbody>
</table>

Table 88 Evidence from the practice case studies to support ‘in any context or discipline creativity’.

<table>
<thead>
<tr>
<th>Case study/evidence</th>
<th>Asking the right questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice case study 1 – ASAP Watercrafts</td>
<td>Interviews and observations with beach emergency workers to identify the solution space.</td>
</tr>
<tr>
<td>Practice case study 2 – Loughborough Service Design Jam 2014</td>
<td>Interaction design academics and service designers to learn about a range of service design methods and prototyping techniques.</td>
</tr>
<tr>
<td>Practice case study 3 – Black+Decker garden power tools range</td>
<td>Interviews and observations with target market to identify opportunities of innovation for the upcoming power garden tools range.</td>
</tr>
</tbody>
</table>

Table 89 Evidence from the practice case studies to support ‘asking the right questions’.

Tables 83-89 presented the supporting evidence identified from the case studies that check the reliability of the consensus definitions of design thinking developed from thematic and content analysis.

### 6.9.3. Conclusions from case study analysis

From the case study analysis the following conclusions were established. The following common characteristics were identified from all of the case studies: experts, processes (CC), ‘design problem’, traditional or non-traditional, multidisciplinary and knowledge. Five of the case studies with the exception of the Loughborough Service Design Jam provided strong evidence for the following common characteristics: drivers and impact. All of the common characteristics identified were matched with suitable modes of expressions identified from the case studies. Finally using the case study analysis the reliability of the two consensus
definitions of design thinking developed from thematic and content analysis was evaluated.

6.10. **Summary of Chapter 6**

This Chapter presented the case studies selected for case study analysis conducted to check the reliability of the findings from literature review and data analysis. From the analysis the following common characteristics were identified from all the case studies: experts, process (CC), ‘design problems’, traditional or non-traditional, multidisciplinary and knowledge. The common characteristics of drivers and impact were only identified from five case studies. From the analysis all common characteristics were matched with their modes of expressions. Finally the reliability of the two consensus definitions of design thinking was also checked by case study analysis.
### 6.10.1. Overall progress summary

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Where was the concept of design thinking first articulated?</td>
<td>✓</td>
<td>Lit Review (2.2); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do academic and practitioner interpret design thinking differently?</td>
<td>✓</td>
<td>Lit Review (2.3.1 &amp; 2.4); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.2.1, 2.3.1 &amp; 2.5); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td></td>
<td></td>
<td>✓</td>
<td>Lit Review (2.3.1); Interviews and online survey (5.4)</td>
<td></td>
</tr>
<tr>
<td>5. How is design thinking expressed?</td>
<td>✓</td>
<td>Interviews and online survey (5.4); case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 90: Progress summary after Chapter 6

- ✓: Question answered
- : Question not answered
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td>✓</td>
<td>Interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td>✓</td>
<td>Lit Review (2.2.1 &amp; 2.3.1); interviews and online survey (5.4); case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does design thinking as incorporated in designing within academia match academic articulation of the concept?</td>
<td>✓</td>
<td>Case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?</td>
<td>✓</td>
<td>Case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 91 Progress summary after Chapter 6 (Continued from Table 123)
Chapter 7 - A qualitative data driven model of design thinking
7.1. **Introduction**

This chapter presents a qualitative data driven model of design thinking alongside the visuals created for it. The model was created by the findings from the research so far. The chapter presents the four different stages of the model:

1. A data driven consensus definition of design thinking
2. Design thinking’s common characteristics
3. Design thinking’s modes of expressions
4. A potential sequence of design thinking application

The diagram below show the structure of the model:

![Figure 108 Structure of the model]

The aim behind using this structure for the model was to help create a better understanding of design thinking as well as make it a clear way to present the findings of the research.
7.2. A generic data driven consensus definition of design thinking

7.2.1. Articulated definition of design thinking

An articulated definition of design thinking was created by combining the two consensus definitions together. The reason behind combining them together was to create a focus point to present the findings from thematic analysis. The articulated definition would then be used as the starting point for a qualitative data driven model of design thinking. In addition to being the starting point of the model the definition would also be used as a tool to help explain the subsequent stages of the model. To create the articulated definition of design thinking the consensus definitions were taken apart and a side by side comparison was conducted to see how the definitions can be combined. Table 92 showed the two consensus definitions taken apart with lined up next to each other alongside the articulated definition of design thinking created from the two definitions:

<table>
<thead>
<tr>
<th><strong>Academic consensus definition</strong></th>
<th><strong>Practice consensus definition</strong></th>
<th><strong>Articulated definition of design thinking</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design thinking is a designerly approach to problem solving...</td>
<td>A collection of human centred design-led problem solving processes or approaches...</td>
<td>Design thinking is a collection of designerly approaches and methods...</td>
</tr>
<tr>
<td>...that can be used divergently</td>
<td>...that address ill-defined problems...</td>
<td>...of problem solving...</td>
</tr>
<tr>
<td>...to solve problems in any context</td>
<td>...in any context or disciplines creativity...</td>
<td>...that can be used in any context...</td>
</tr>
<tr>
<td>...and create solutions by using the suitable expertise and knowledge</td>
<td>...by focused questioning</td>
<td>...to generate solutions creatively by employing the suitable expertise and knowledge.</td>
</tr>
</tbody>
</table>

Table 92 Side by side comparison of the two definitions

By combining the two consensus definition of design thinking, the following articulated definition of design thinking was created:

*Design thinking is a collection of designery approaches and methods of problem solving that can be used in any context to generate solutions creatively by employing the suitable expertise and knowledge.*
Referring back to the data analysed the articulated definition incorporated the similarities and difference between academia and practice. Doing so had created a definition that can be used to help further understand what design thinking could be.

7.3. **Design thinking's common characteristics**

The common characteristics of design thinking make up the second stage of the model. In this stage the common characteristics are presented alongside the examples given by academics and practitioners therefore showing the differences and similarities between the two. Furthermore the examples also helped to create a more tangible way of presenting the common characteristics. Figures 109 and 110 show how the common characteristics and their information are visually presented in the model.
Common characteristics icons:

![Common characteristics icons](image)

*Figure 109 Design thinking’s common characteristics icons.*

Evidence source and methodology icons:

![Evidence source and methodology icons](image)

*Figure 110 Evidence source and methodology icons for the model*
Design thinking is defined by the following 7 Common Characteristics:

<table>
<thead>
<tr>
<th>Evidence source</th>
<th>Common Characteristics</th>
<th>Similarities</th>
<th>Academic differences</th>
<th>Practitioner differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drivers</td>
<td>Budget, objectives, technology</td>
<td>Design for sustainability</td>
<td>Market, human centred</td>
</tr>
<tr>
<td></td>
<td>Experts</td>
<td>Industrial designers, service designers</td>
<td>Design schools, design academics &amp; researchers</td>
<td>Design thinking company, consultants</td>
</tr>
<tr>
<td></td>
<td>Impact</td>
<td>USP, disruptive innovation, patents</td>
<td>Knowledge generation, social innovation</td>
<td>Creative formula, engaging users</td>
</tr>
<tr>
<td>Process (CC)</td>
<td>‘Design problems’ T/NT*</td>
<td>Design (verb), user centred design, co-design</td>
<td>Research of design, design research</td>
<td>Innovation management, creative processes</td>
</tr>
<tr>
<td></td>
<td>Multidisciplinary</td>
<td>Industrial design, service design, interaction design</td>
<td>Design education</td>
<td>Business design, design management</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td>Insights identified from research or given by experts</td>
<td>Insights identified from research or given by experts</td>
<td>T-shaped</td>
</tr>
</tbody>
</table>

*‘Design problems’, traditional or non-traditional

Figure 111 Design thinking model stage 2
7.4. Design thinking’s modes of expression

Design thinking’s modes of expressions made up the third stage of the model. In this stage the modes of expressions were presented alongside their evidence and the origins of the evidence. In addition to the evidence the common characteristics and their modes of expressions were also presented therefore providing examples for the users. The figures on the following pages present the third stage of the model.

Modes of expression icons:

![Figure 112 Design thinking’s modes of expressions icons](image-url)
Design thinking is expressed by the following Modes of Expressions:

<table>
<thead>
<tr>
<th>Evidence source</th>
<th>Common Characteristics</th>
<th>Modes of Expressions</th>
<th>Examples of ME</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Drivers</td>
<td><img src="image2" alt="Drivers icon" /></td>
<td>Budget, technology, need of a new logo</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Experts (interact via)</td>
<td><img src="image3" alt="Experts icon" /></td>
<td>A design academic teaching sketching, how to use CAD</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Impact</td>
<td><img src="image4" alt="Impact icon" /></td>
<td>A new smartphone with patented USPs and being the lightest</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Process (CC)</td>
<td><img src="image5" alt="Process icon" /></td>
<td>Sketching, co-design, brainstorming, prototyping</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>‘Design problems’ T/NT*</td>
<td><img src="image6" alt="‘Design problems’ icon" /></td>
<td>Design a chair that fit 99% of the population, improve the NHS</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Multidisciplinary</td>
<td><img src="image7" alt="Multidisciplinary icon" /></td>
<td>Service design, business design, product design</td>
</tr>
<tr>
<td><img src="image1" alt="Evidence source icon" /></td>
<td>Knowledge (pass on via)</td>
<td><img src="image8" alt="Knowledge icon" /></td>
<td>A service designer mentoring at a service design workshop</td>
</tr>
</tbody>
</table>

*‘Design problems’, traditional or non-traditional

Figure 113 Design thinking model stage 3
7.5. **Design thinking's potential application sequence**

The fourth stage of the design thinking model was the potential application sequence of design thinking. The potential application sequence of design thinking was identified from case studies analysis. The application sequence presented used the case studies from the case study analysis as examples. The model then matched them up with the common characteristics and modes of expressions. The figures on the following pages present the fourth stage of the model.
### Matching the common characteristics and modes of expressions with case studies:

<table>
<thead>
<tr>
<th>Academic case studies</th>
<th>Common Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treezex location device</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Lumo</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Mom, inflatable incubator</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice case studies</th>
<th>Drivers</th>
<th>Experts (interact via)</th>
<th>Impact</th>
<th>Process (CC)</th>
<th>Design problems T/NT*</th>
<th>Multidisciplinary**</th>
<th>Knowledge ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASAP Watercrafts</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
</tr>
<tr>
<td>Lufbra Service Design Jam, March 2014</td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
<td><img src="image13.png" alt="Image" /></td>
<td><img src="image14.png" alt="Image" /></td>
<td><img src="image15.png" alt="Image" /></td>
<td><img src="image16.png" alt="Image" /></td>
<td><img src="image17.png" alt="Image" /></td>
</tr>
<tr>
<td>Black+Decker power garden tools range</td>
<td><img src="image18.png" alt="Image" /></td>
<td><img src="image19.png" alt="Image" /></td>
<td><img src="image20.png" alt="Image" /></td>
<td><img src="image21.png" alt="Image" /></td>
<td><img src="image22.png" alt="Image" /></td>
<td><img src="image23.png" alt="Image" /></td>
<td><img src="image24.png" alt="Image" /></td>
</tr>
</tbody>
</table>

---

*Design problems*, traditional or non-traditional  
**Multidisciplinary**  
***Knowledge (pass on via)***

**Figure 114 Design thinking model stage 4**
### Potential design thinking application sequence identified from case studies:

<table>
<thead>
<tr>
<th>Application steps</th>
<th>Case studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Drivers</td>
<td>Lack of gardening tools range within Black+ Decker</td>
</tr>
<tr>
<td>2. ‘Design problems’ T/NT*</td>
<td>Traditional design problem</td>
</tr>
<tr>
<td>3. Multidisciplinary**</td>
<td>Traditional design problem</td>
</tr>
<tr>
<td>4. Experts</td>
<td>Traditional design problem</td>
</tr>
<tr>
<td>5. Knowledge</td>
<td>Traditional design problem</td>
</tr>
<tr>
<td>6. Process (CC)</td>
<td>Traditional design problem</td>
</tr>
<tr>
<td>7. Impact</td>
<td>Traditional design problem</td>
</tr>
</tbody>
</table>

---

**Design problems’, traditional or non-traditional  **Multidisciplinary

---

*Figure 115 Design thinking model stage 4*
7.6. Summary of Chapter 7

This Chapter presented a data driven model of design thinking. The model presented in this chapter was created from the findings of the research so far. Design thinking was defined by the seven common characteristics identified from the literature review, pilot studies and data analysis as presented in stage 2 of the model. Then design thinking was expressed by any of the modes of expressions identified from data analysis and literature review presented in stage 3. Finally a potential design thinking application sequence was identified from the case study analysis presented in stage 4.
## 7.6.1. Overall progress summary

<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Where was the concept of design thinking first articulated?</td>
<td>✓</td>
<td>Lit Review (2.2); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Do academic and practitioner interpret design thinking differently?</td>
<td>✓</td>
<td>Lit Review (2.3.1 &amp; 2.4); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.2.1, 2.3.1 &amp; 2.5); interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Can a ‘generic’ design thinking model be created from academic and practitioner interpretations?</td>
<td>✓</td>
<td>Lit Review (2.3.1); interviews and online survey (5.4); DT model (7.1 – 7.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 How is design thinking expressed?</td>
<td>✓</td>
<td>Interviews and online survey (5.4); case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 93 Progress summary after Chapter 7
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Answered</th>
<th>Method used (Sections)</th>
<th>Somewhat answered</th>
<th>Method used (Sections)</th>
<th>Not answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td>✔️</td>
<td>Interviews and online survey (5.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td>✔️</td>
<td>Lit Review (2.2.1 &amp; 2.3.1); interviews and online survey (5.4); case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Does design thinking as incorporated in designing within academia match academic articulation of the concept?</td>
<td>✔️</td>
<td>Case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?</td>
<td>✔️</td>
<td>Case study analysis (6.2 – 6.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 94 Progress summary after Chapter 7 (Continued from Table 126)
Chapter 8 - Validation studies
8.1. Introduction

This Chapter presents the evaluation study conducted to validate the research. The studies evaluated the following aspect of the research: methodology used, research approach, 7 common characteristics of design thinking, design thinking’s modes of expression, a generic data driven consensus definition of design thinking and a qualitative data driven model of design thinking. The reliability of the data gathered was achieved by triangulation. Table 95 presents a summary of the methods employed for data gathering to ensure reliability on all data used to answer the research questions:

<table>
<thead>
<tr>
<th>Research question</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1: Where was the concept of design thinking first articulated?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 2: Has the meaning of design thinking changed since the 1960s?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 3: Do academic and practitioner interpret design thinking differently?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 4: Can a generic design thinking model be created from academic and practitioner interpretations?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 5: How is design thinking expressed?</td>
<td>Method 1 Interview and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 2 Case study analysis</td>
</tr>
<tr>
<td></td>
<td>Method 3 Literature review</td>
</tr>
<tr>
<td>RQ 6: Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interview and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 7: Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?</td>
<td>Method 1 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 2 Case study analysis</td>
</tr>
<tr>
<td></td>
<td>Method 3 Literature review</td>
</tr>
<tr>
<td>RQ 8: Does design thinking as incorporated in designing within academia match the academic articulation of the concept?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
<tr>
<td>RQ 9: Does design thinking incorporated in designing within practice match practitioner articulation of concept?</td>
<td>Method 1 Literature review</td>
</tr>
<tr>
<td></td>
<td>Method 2 Interviews and online survey</td>
</tr>
<tr>
<td></td>
<td>Method 3 Case study analysis</td>
</tr>
</tbody>
</table>

Table 95 Summary of methods used in the research for triangulation
As shown in Tables 128 and 129; each research question was answered with data gathered from three methods. As discussed in Chapter 3.2.3, all data collection methods used the same content to ensure the consistency in the data gather. Therefore, allowing the reliability in the data to be achieved through triangulation.

Validity of the research was achieved through the evaluation studies conducted. The evaluation studies examined one of the issues of qualitative research: interpretation. In the case of this PhD, the interpretation aspect was the understanding of the data gathered and using the findings to create outcomes (design thinking model, see Chapter 7) of the research conducted. According to Robson (2011: 156-157), the main threat of unable to provide a valid interpretation of the research conducted is through imposing a framework or meaning on what is happening rather than learning what is occurring or emerging from the data and settings. This means without a prefixed research framework, the steps taken to the interpretations must be examined. To demonstrate validity in the interpretation of the data gathered, Mason (1996: 150) suggested that validity is to be achieved by continually charting and justifying the steps taken. Using Mason’s suggestion as a guideline, the evaluation study was designed to present the steps taken to interpretation and used the member checking approach (Robson, 2011: 158) to validate if the steps taken were suitable. Here, the members involved were PhD students and research staff from Lancaster University and design practitioners teaching part time at Loughborough University. The evaluation study design will be discussed in the upcoming section.

8.2. Validation study

Originally the validation method was a Delphi study. However, due to logistical issues and participants not being available due to teaching and working commitments; an alternative strategy was created. The alternative strategy was to use a seminar environment to validate the research; conducting two seminars for academics and practitioners. Using Mason’s suggestion (1996:150) and the member checking approach (ibid: 158) as a guideline; the format of the seminar was the following; research presentation...
then feedback and discussion. As a result a presentation summarising the PhD was created. The content of the presentation was the following:

- Methodology used and research approach
- Literature review and its findings
- Research instrument design and pilot studies
- Data collection
- Data analysis method used and its findings
- Case studies analysis
- A qualitative data driven model of design thinking

Figures 116-119 show a few examples slides of the presentation used for the evaluation study:
What is design thinking?
A PhD research overview

INTRODUCTION

Figure 116 Example slides of the presentation used for evaluation
METHODOLOGY USED

- Methodological stance: Constructivist grounded theory
- Mixed qualitative method strategy
- Triangulation for reliability

Figure 117 Example slides of the presentation used for evaluation
LITERATURE REVIEW FINDINGS

- 4 Common Characteristics (CDs) identified:
  - Drivers
  - Experts
  - Impact
  - Process (GC)

Figure 118 Example slides of the presentation used for evaluation
Figure 119 Example slides of the presentation used for evaluation

For the full presentation please refer to Appendix 16. All participants were also given a guide for reference purposes during the presentation, for the guide please refer to Appendix 17.
8.3. Academic validation seminar findings

The seminar was held at Imagination Lancaster, Lancaster University on the 28th January 2015. The seminar was 90 minutes long and the participants were PhD students, research and teaching staff of the department. The following feedback was gathered.

Methodology and research approach

The participants agreed the methodology and research approach used was suitable for the research. The participants did not provide any alternative methodology or research approach.

Literature review and findings

The participants found the range of literature reviewed sufficient. However, one question was raised regarding if other fields were discussing design thinking in literature:

At the beginning you show the literature review you show the right hand side the book you read. Most of those books where from the discipline of design. Did you find from the literature of the 1960s that other disciplines were talking about design thinking? I know what you are saying were about application in management and business. I wonder if people were talking about it in another time.

Research instrument design and pilot studies

The participants did not comment on the research instrument design, pilot studies and their findings.

Data collection

The participants believed the data collection used was suitable for a qualitative study. No alternatives were provided.
Data analysis method used and findings

The participants believed the data analysis methods used were suitable for the study. The participants, however, gave feedback related to the common characteristics of design thinking identified. The participants suggested further refinement for the common characteristics: impact, experts and knowledge would be beneficial. They gave the following feedback for the common characteristics impact:

‘The impact seems to be that it exists, therefore, it has impact. A prototype was created therefore the impact box is ticked. For me impact is the effect on the user or the user experience. What stands out to me like the Lumo, is it the Lumo? To me the impact is not the physical form but the impact is what impact it has on the children who are using it. So there is a bit of an empty space for me. Clearly being an academic product or a student product there is no impact being measured. Again with the Service Design Jam there seems to be no impact and the impact does not count again is worrying in my mind because designing a service is just as valid if not more in some places. It is the whole kind of impact I think could do with a good look.’

‘You have chosen academic case studies that were just created now. If you look at academic case studies that were created five years ago and see if impact and to see what it did. So if it was done five years ago and it helped save some people life and it would help reduce travel times for ambulances and that is a recognisable impact.’

‘Would it help to think of it certainly in terms of evaluation process used in NGO programs? So you use output, outcome and impact. Output would be the physical form, outcome is that it could be in production and impact is that it saved so many lives. A spectrum of impact.’

In addition, the following feedback was given to the common characteristics experts and knowledge:
‘I had a question it is about two of the common characteristics of design thinking. It is about experts and knowledge. So reading here it said experts are people from different disciplines... Knowledge is provided... I guess my question is: is there an instance where experts do not provide knowledge? I can understand why one is a person; one is sort of a thing they use or have.’

**Case study analysis**

The participants agreed case studies analysis was a suitable method of ensuring reliability in the data gathered. However, they identified that the bias towards the discipline industrial/ product design was an area of concern:

‘I was wondering at the beginning of the research how did you set the disciplinary boundaries of your investigation in terms of what you use as case studies and people to interview? Because it seems very product design orientated.’

In relation to the bias towards using industrial/ product design case studies, the participants suggested the field of enquiry might have been limited due to the bias towards a discipline:

‘Sorry does that limit the whole field of enquiry of the study of the PhD that it ended up with one reason or another because focused on product design rather than design thinking in design?’

**A qualitative data driven model of design thinking**

The participants believed the model was a useful summary of the findings from this PhD. However, the participants identified the following areas of concern. One participant commented on the model’s uniqueness when compared to others and the research’s contribution to knowledge:

‘You draw out a model, you referred to literature review and this model is related to product design maybe it cannot fit another type of design. What are the characteristics that make your model distinguish maybe from the other modes they used before they used in design thinking?’
Did you find something new and referring to the other people who were defining design thinking before?’

Another concern identified by the participants was the areas of application for the model:

‘Do you think the model could apply to other design disciplines?’ (...) because Service Design Jam is an event whereas if you take a service and you put it in that model it would work.’

The areas of concern identified by the academic evaluation will be addressed in detail in Chapter 9.

8.4. Practitioner validation seminar findings

The presentation and validation session was held at the Design School with two design practitioners on the 29\textsuperscript{th} January 2015. Between them they had worked in the following fields in the past 20 years: consumer and medical products, shop interiors, special effects for TV and film, technology research and design management. The following feedback was gathered.

\textit{Methodology and research approach}

The participants did not provide any specific feedback on the methodology and research approach. However, when question about the topic after the presentation, both stated the methodology and research approach used was suitable.

\textit{Literature review and findings}

The participants believed the literature reviewed was suitable for the research. However, one participant commented on the literature’s focus on industrial/ product design; the participants believe it could have been beneficial to have a more diverse range of discipline being reviewed in literature:

‘What you have not done is look at fashion, textiles, architecture, graphic design and illustration. It would be nice to look outside the area of product design, just to see what others have to offer.’
Research instrument design and pilot studies

The participants did not comment on the research instrument design and pilot studies.

Data collection

The participants believed the data collection methods used was suitable for a qualitative study. No alternatives were provided.

Data analysis method used and findings

The participants believed the data analysis methods used were suitable. However, they believed the common characteristic drivers were too industrial/product design biased:

The drivers’ examples are very much based upon a user centred approach or need rather than historical context or social reflection. Or something more abstract.

They also believed the common characteristics of design thinking did not represent all aspects of design:

‘Going back to the seven common characteristics of design thinking, something I have been trying to separate now, what I do now. I think it comes to a point that when I design I take a step back and look at the design to see if that is something that moves you, makes me want to buy it. All objects have a voice, you are trying to address the feel and if it is saying the right thing. Does that come under impact? That is sort of gut feeling. Whether you feel something is right or wrong. That is my sort of design thinking; you got to work out if it is right or wrong. You got to work out that magic thing if the right proportion, if you pick it up does it feel good.’

In addition they also believed design thinking’s modes of expression were not clearly communicated across within the findings:

‘When you think design thinking’s modes of expression who is the recipient of those modes of expressions? Are we talking about a client,
a user, someone in the PhD study? As a designer communicating graphically, I don’t like the word graphically. Who am I talking to then?’

**Case study analysis**

The participants believed case study analysis was suitable to identify examples of design thinking application and check the reliability of the data. However, they were critical of the bias towards industrial/product design in the case studies selected:

‘I suppose so. I would like to do more of that. The department is very much focused on this user centred design process to create an object that does not exist in the market. The solution to that is always a product. A good example of that is this product for the kids in separated families. The solution is to create an electronic product or a consumer product. I’d like to see a lot more of the beautiful part of sculpting, dealing with materials and tiny design twists on existing products. Maybe just as creative, in fact it is more difficult to improve the design of a mature object than invent something. It would be nice to see some element of that. I guess this seems to be where it is lacking. Maybe looking at contemporary fine artists and seeing how they are creating their work could help. In fact it is quite simple if you look at Grayson Perry’s Channel 4 show he used a lot of design research process and thinking in that way. User research, user observation technique, reflecting on society, it would be worth looking at just to see how a fine artist is using all these design techniques.’

In addition to the criticism of bias towards one discipline, they also commented on the lack of ‘mature objects’ represented in the research:

‘Yes, so mature objects like a chair, chopping board, knife etc... You can do very beautiful things with mature objects without doing this innovation process. In Loughborough innovation is a big driver isn’t it? You must innovate; you must do this and that. You never see anyone do any mature objects. But that is fine that is the slight bias of the University and you don’t seem to address that aspect of design.’
A qualitative data driven model of design thinking

The participants were critical of the model. They believed it was not a good idea to use it as a blueprint for design education as it could take away the creativity within design:

‘My criticism of using this as a blueprint in design school or university is that it could foster the belief of I have ticked all on the list give me full marks. But you have the job to say this is not exciting, doesn’t move me, not special. What I want to see is something from them that I could have never come up with.’

‘I know why Universities and schools like this because it is easier to access and make sense. It is harder for students to take criticism when you cannot explain it. Sometimes it is hard to explain. I think it is very Loughborough, at Nottingham Trent there is a more fluid approach. Loughborough like to compartmentalise things, I think the way the course developed and people do their own thing. It does feel very compartmentalised at a point.’

They also commented on the model being unintuitive; they believed it could be hard for others outside academia to understand it:

‘If I were to comment on, the reason I asked what use is it. If this is for students to use and help their critical thinking and designedly thinking I find it quite confusing separating things out in this way. It does not feel intuitive to me at all. I can recognise the bits and pieces but I found it difficult to follow.’

In addition to being unintuitive, they also commented on it being unsuitable to present something that is fluid and organic (design thinking). From their viewpoint it was a rather ‘mechanical way’ of presenting the model and made the subject harder to understand:

‘It is not... in separating it out this way... It is not part of my knowing. I recognised these things in the processes. Separating them is like rather explaining a joke. The moment you take the joke apart... It is very complex why we would find something funny but in explaining it
you lose the humour... So much of design is all our experiences and we bring so much in we are not conscious of and indeed our biases like your product design bias. Doing it in this mechanical way seems to miss out on that special thing from the heart, that individual thing that you bring to it and make it rather cold and clinical.’

‘Even compartmentalisation is what I am also struggling with. The reduction of some of these compartmentalised subject areas you have chosen could be PhD subjects in their own right. They are also trivialised here. They were very limited in the way you summarised them and limited in the way of what they mean.’

‘It makes sense but again you are missing something there by splitting it up like this. The Jet Ski got to where it is because of who is driving it. The way he looks, his characteristics and his personality. I think that is why it is successful because of a charming guy driving it.’

Finally they believed the model does not address or represent the emotional side of design:

‘I always think of a range of products ranging from needed, like a scalpel blade; very basic to want for something you don't need but something that is so beautiful that you want to buy. I just want this in my life. And in between you have the ‘I wanted to believe it’ type where like a Dyson it expresses this scientific efficiency like best performance or whatever. So are you saying that we don't do enough of the beauty and exploration of the aesthetics of products?’

‘Yes all the products we buy and surround ourselves with are expressions of ourselves and personality. The houses you live in, clothing you wear and sometimes that is quite a subconscious thing and it is quite hard to measure.’

The areas of concern identified by the practitioner evaluation will be addressed in detail in Chapter 9.
8.5. Summary of Chapter 8

To summarise, both academic and practitioner validations believed the methodology and research approach, literature reviewed, data collection methods used and data analysis methods were suitable for the research. However, the validation also identified areas of concern. These will be discussed in detail in Chapter 9.

The academic validation identified the following areas of concern:

- Range of literature reviewed
- Refinement of three common characteristics (impact, experts and knowledge)
- Bias towards industrial/product design
- Limitation of the study caused by bias towards one design discipline
- Area of application for the model
- What is unique about the model and its contribution to knowledge.

The practitioner validation identified the following areas of concern:

- Bias towards one discipline
- The common characteristics of design thinking do not represent all aspects of design
- Design thinking’s modes of expression were not clearly communicated; possible further development required.
- Bias towards one discipline in case study analysis
- Lack of ‘mature objects’ represented in the research
- The model should not be used as a blueprint of design education
- The model does not represent the emotional side of design
• The model was unintuitive.
Chapter 9 - Discussion
9.1. Introduction

This Chapter discusses the research conducted, research findings and the feedback given in the validation studies. It discusses and reflects upon the following areas: reliability and validity of data collection methods and research strategy; discusses and compares the research findings to literature; similarities and differences in academic and practitioner viewpoints of design thinking within the research findings; comparison of the design thinking model to others and feedback from the validation studies.

9.2. Reliability and validity of the data collection methods and research strategy

The research employed three different data gathering methods; they were interviews, online survey and case study analysis. The data collected yielded new common characteristics and supporting evidence for all 7 common characteristics. This section discusses and compares the data collected via the different data collection methods for each common characteristic.

Drivers

Drivers was one of the four common characteristics identified from literature review. The majority of the supporting evidence for the common characteristic was gathered through interviews and online survey responses. From the interview data, it appeared that when asked about giving out examples of drivers, some interviewees struggled to provide them during the interview. This could be caused by the interviewees having years of experience in their fields; therefore, making it difficult to identify examples of drivers on the spot. The interviews were semi-structured (discussed in Chapter 3.2.7) to allow the participants to express their views freely within the boundaries of the topic; as a result, led to the gathering more in depth data compared to online survey. The depth of the data compensated to the lower number of clear cut examples. Because of the depth of the interview data, it could be said that more than half the supporting evidence was identified from the interview data through content analysis.
The participants of the online survey appeared to have provided more examples of what drivers were. While there were more examples of drivers from the survey data; it must be noted that there were more survey participants than interviewees (43 compare to 13) and the environment could have also contributed towards this. Here, it means the participants were in an environment that they were comfortable in, for example their homes or offices. Being in their own or natural environment could have helped them to provide more examples when conducting the survey. Despite the higher number of examples the data from the survey was not as in depth as the interview data. Another interesting finding from the survey data was that the participants provided examples of what they believed not to be drivers in their field of work and expertise. Those examples were useful during coding as it helped to further develop the sub-categories.

Comparing to the data gathered by interview and online survey; the data generated by case study analysis was a mixture of both. This was because the data that were identified as evidence appeared in their natural environment; in this case, the log books and portfolios provided by the participants. The depth of the data was similar to the interview data set. From the case study analysis, the evidence for drivers was identified with ease compare to the interview data. The ease of identification could have been caused by the material available during the analysis.

From the three data sets; the strengths of them were the following:

- Interview data had the most depth and detail descriptions of what drivers could be.

- Online survey data provided a greater variety of driver examples; non-drivers examples provided also provided richness to the evidence.

- Case study analysis data provided detail examples of drivers in their natural environment.

Their weaknesses were:
• Interview data’s driver examples were not as devised when compared the online survey ones.

• Compared to the interview and case study analysis examples, the online survey ones lack depth and detail.

• The case study analysis examples were discipline focused.

Overall the three data sets combined well because the interview and case study sets provided the depth for the evidence and the online survey set provided the divinity for evidence.

*Experts*

Experts was one of the common characteristics identified from the literature review. The majority of the supporting evidence for the common characteristic was gathered through interviews and online survey. During the interviews, the participants appeared to find it easier to give examples of experts. The design thinking application examples given during the interview often started with the experts who were involved in those projects; as a result, it was relatively straightforward to identify the evidence during content analysis. Perhaps giving examples of experts were easier than drivers because the interviewees worked alongside them; therefore, making it easier to remember.

However, from the online survey data set the identification of evidence for experts was more difficult. When comparing to the interview data set apart from being less in depth, the data also had less examples of experts. The lower number of examples could be down to the nature of online survey as a method. Firstly part 1 of the Design Thinking Survey was the only part that all participants must fill in, as it was needed to separate the academics and the practitioner. Part 2 of the survey did not enforce such rules; as a result of this, some of the participants appeared to skip questions and led to the lack of examples. Another factor that could have caused that might have been the fixed structure of questioning and the lack of adaptability due to the researcher not being there. The lack of interaction between researcher and
participants appeared to have caused lower numbers of experts examples generated with this data set.

Examples of experts were easily identified from case study analysis. The ease of identification was caused by the nature of the case study samples. As a result of using product design and service design projects, the involvement of experts were well documented during the beginning of all projects by the participants. The documentation and presentation of the case study made it easy to identify those examples and this was similar to the interview data set.

Between the three types of data, their strengths were the following:

- Interviews data set provided in depth and good range of experts examples.
- Online survey data set provided disciplined focused examples
- Case study analysis data set provided detail examples in their natural environment.

Their weaknesses were:

- The range of examples provided by the interview data set was not as devised as expected.
- From the online survey data set the examples lack depth.
- The weakness of case study analysis data set examples was similar to the interview data set.

When compared to identifying examples for the common characteristic drivers; the process for experts was easier. This appeared to be caused by the examples provided in the data sets. Furthermore, out of all the evidence of common characteristics, the evidence for the common characteristic experts was the closest to each other in terms of examples and contexts in which they emerged.
Impact

Impact was the third common characteristic identified from the literature review. Majority of the evidence for this common characteristic was gathered through interviews, online survey and case study analysis. During the interviews; when asked to provide examples, the participants found it easier than providing examples for the common characteristic drivers. From the interviews, a wide range of examples were gathered. They were easily identified during content analysis.

The online survey yielded similar examples to the interview data sets. When compared to data belonged to other common characteristics gathered through online survey; it appeared impact had the most examples and had the most depth. Furthermore, the participants of the online survey also provided a diverse range of examples from different fields (government services, business, education and healthcare). The bulk of the evidence for this common characteristic was built upon the evidence gathered through interviews and online survey.

The case study analysis data set again produced the evidence in their natural environment. When compared to the other two data sets, the evidence from this method was the most detailed. Here, it meant the evidence can be traced from the start to end of a design project. The points where the impact originated could be pinpointed and that helped to shape the common characteristic better as it provided more contexts for better articulation.

From the three data sets, their strengths were the following:

- The interview data set provided a wide range of examples of what impact was.
- The online survey data set provided further diversity for the evidence gathered.
- The case study analysis data set had the most depth and context.

Their weaknesses were the following:
• The interview data set’s examples were not as in depth as expected. This could be caused by the participants were not at liberty to discussed the projects they recently conducted.

• The online survey data set’s examples were diverse; however, some of the examples provided were not cleared within the contexts in which they emerged. As a result not all examples were coded.

• The online survey data set examples’ weakness was that they were disciplined focused; while it added depth and contexts to the evidence, it did not provide as much ‘new’ data.

From the three sets of data, it could be said that the evidence for the common characteristics within certain design disciplines (product design and service design) were stronger than others. Again the interviews and case study analysis data sets provided majority of the evidence. The data would have benefited with more examples from different design disciplines.

**Processes (CC)**

*Processes (CC)* was the final common characteristic identified from the literature review. Majority of the evidence for this common characteristic was gathered through interviews and online survey. From the interviews, the interviewees provided plenty of examples of processes that are related to design thinking. The examples from the interviews were a mixture of processes from product design, service design, sustainable design and business. The supporting evidence for the common characteristic was built upon the interview data set.

The online survey data set yielded similar data to the interview data set. The difference between the two was the depth of the data and less number of examples. From the online survey responses it appeared processes was another common characteristic that the survey participants found difficult to provide examples for. This could be caused by the participants unwilling to disclose the processes they used in their businesses. This was a similar issue to the common characteristic *experts*. Furthermore, this could also be
caused by the lack of interaction between participants and researcher similarly to the issue encountered with experts.

The case study analysis data set provided in depth data on the common characteristic. From the case study analysis data set, there were detail description and evidence of the processes used in the case studies. Despite the depth of the data, the limitation was majority of the processes described were related to product design and service design. As a result, the case study data set did not add more ‘new’ data towards the evidence.

From the three data sets, their strengths were:

- The interview data sets provided a wide range of in depth examples of processes the participants used when employed design thinking.
- The online survey data set echoed the findings of the interview findings; adding more to the bulk evidence.
- The case study analysis data set provided a detail view of a number of processes being used in their natural environment. The information helped better articulate the evidence for the common characteristic.

Their weaknesses were:

- The interview data set could have benefited with evidence of processes from a wider range of disciplines.
- The online survey data set did not yield as many examples.
- The case study analysis data set did not add more ‘new’ data towards the evidence.

Overall from the three data sets, it appeared the online survey had difficulty generating data for the common characteristic. This was however, compensated by the findings yield from the interviews and case study analysis data sets.
'Design problems', traditional or non-traditional

‘Design problems’, traditional or non-traditional was a common characteristic identified from the pilot studies. As a result of its identification, the research instrument was updated accordingly (discussed in Chapter 4.7-4.9). During the interviews the interviewees did not provide as many clear definitions of what they believed to be traditional or non-traditional design problems. However, the identification of the evidence for the common characteristic was not as difficult during content analysis because of the contexts in which they emerged. The interview data set provided a good base to build the evidence upon. The contexts in which the data emerged were key to building evidence for this common characteristic.

The online survey data set provide a variety of examples of what the participants believed to be traditional or non-traditional design problems. When compared to the interview data set, the data provided by the survey participants were at time more defined than the interviewees. Here, it means the participants would provide their view on the common characteristic along with an example. The variety of examples identified provided the richness towards the evidence for the common characteristic.

The case study analysis data set yield more evidence for traditional design problems. This was caused by the samples of case studies available when the analysis was conducted. There was also evidence for non-traditional design problems but there was less; this was caused by the samples available. Overall the case study analysis data set provided detail description of traditional or non-traditional design problems and the details helped better articulate the common characteristic.

From the three data sets, their strengths were:

- The interview data set provided rich contexts for the evidence to be built upon.
- The online survey data set provided a variety and clear description of traditional or non-traditional design problems.
• The case study analysis data set provided detail description of 
  traditional or non-traditional design problems.

Their weaknesses were:

• The interview data set did not provide as many examples as 
  expected.

• Despite the variety and clear description, not all examples were 
  usable from the survey data set due to lack of contexts for some 
  of them.

• Bias towards product design and service design as those were the 
  samples available at the time.

Overall the three data sets provided data that were similar to each other; 
therefore, enable each data set to compartment each other and filled in their 
weaknesses. However, the evidence could have benefited with a wider range 
of case studies from other design disciplines.

**Multidisciplinary**

**Multidisciplinary** was a common characteristic identified from thematic 
analysis. During the interviews, the interviewees gave plenty of examples of 
design thinking being multidisciplinary. The interviewees used the examples 
to showcase the different disciplines that employed design thinking. 
Furthermore, they also provided the contexts in which the disciplines would 
become involved. The contexts provide information to better articulate the 
common characteristic. The interview data set formed the basis of the 
evidence.

The online survey data set complemented the interview data set. From the 
survey responses, the participants provided data similar to those gathered 
from the interview data set. In terms of variety of examples given it was not 
as great as evidence for some other common characteristic yielded from 
online survey.

The case study analysis data set provided detailed examples of 
multidisciplinary through the documents provided by the participants. From
the documents provided examples of the different fields and design disciplines involved with the case studies were clearly recorded. The data further add to the evidence identified from the other two data sets.

From the three data sets their strengths were:

- The interview data set provided examples of *multidisciplinary* within design thinking. The contexts included helped to articulate the evidence for the common characteristic.

- The online survey data set appeared to add further evidence to the interview data set and provided more variety for the common characteristic.

- The case study analysis data set provided detail examples in their nature environment.

Their weaknesses were:

- Majority of the examples provided from the three data sets were related to product design or service design. As a result there was an element of bias towards these two disciplines.

**Knowledge**

*Knowledge* was the final common characteristic to be identified. It was identified through thematic analysis. From the interviews, the interviewees did not provide many examples when compared to other common characteristics. While knowledge was identifiable through the interview data, not many examples were identified. It appeared the interviewees mentioned knowledge but did not expand upon the topic. The same could be said for the online survey data set.

Compared to the interview data set, the survey data set was worse. It had even fewer examples and it seemed the participants found it difficult to discuss the common characteristics with their responses. The difficulty encountered by the interviewees and survey participants could be down the question design or *knowledge* being a difficult topic to provide examples for.
However, the case study analysis data set appeared to be the most successful in generating data and examples for the common characteristic’s evidence. The knowledge used in those case studies was clearly documented and display through the materials provided by the participants. The ease of identification of knowledge from case study analysis could be down to the fact that the common characteristic was not something that was as easy to articulate or obvious as some other common characteristics. The nature of case study analysis as a data collection method: analysing data in its natural environment helped the identification of evidence for knowledge. The case study data suggested it was a well-documented characteristic within design thinking application; however, articulating and describing it may be difficult due to the question design of the other two methods. Perhaps as a result of that, the interviewees and survey participants found it difficult to provide examples for when questioned.

From the three data sets, their strengths were:

- The interview data set provided the identification of the common characteristic.
- The case study analysis data set provided the evidence to support the identification of the common characteristic.

Their weaknesses were:

- The interview and online survey data sets did not provide many examples related to the common characteristic; as a result, the supporting evidence had to come from case study analysis. Due to the lack of examples from these two data sets, the supporting evidence for this characteristic appeared to be the weakest out of the seven.
- The case study analysis provided the evidence to support the common characteristic; however, due to the lack of data from the other two data collection methods the evidence collected was not triangulated as intended thoroughly.
While this common characteristic was identified through the three methods, its evidence appeared to be the weakest due to the reasons discussed. This common characteristic would benefit from further development through more specific questioning when conducting the research.

Reliability for supporting evidence was gathered through the sampling techniques employed (discussed in Chapter 3.1.6). The sample techniques ensure the participants selected were the most suitable. Therefore ensuring the data generated to be similar in terms of quality.

9.3. Comparison and discussion of the research findings in relation to literature

This section compares and discusses the research findings to published literature. From the research the following findings were established:

- Design thinking’s 7 common characteristics: drivers, experts, impact, processes (CC), ‘design problems’ traditional or non-traditional, multidisciplinary and knowledge.

- Similarities and differences between academics and practitioners perspectives.

The discussion follows the order of the findings presented above.

9.3.1. The 7 Common characteristics of design thinking in relation to literature

From the initial literature review (see Chapter 2.5), pilot studies and thematic analysis the following common characteristics were established: drivers, experts, impact, processes (CC), ‘design problems’, traditional or non-traditional, multidisciplinary and knowledge. These common characteristics were developed from empirical research and their supporting evidence was identified through thematic analysis and content analysis (see Chapters 5.4.1-5.4.4).

Comparing the research findings to additional literature (Baeck and Gremett, 2011; Brown and Martin, 2015; Blizzard, Klotz, Potvin, Hazari, Cribbs and Godwin, 2015; Goldschmidt and Rogers, 2013; Lloyd, 2011;
Kolko, 2015; Yoo and Kim, 2015) it appeared that these seven common characteristics could be identified. This section compares the seven common characteristics to the following:

- Blizzard et al’s (2015) design thinking traits
- Berger’s (2009) Glimmer Principles
- Baeck and Gremett’s (2011) core attributes of design thinking
- Other authors who have indirectly reveal aspects of design thinking

**Blizzard et al’s (2015) design thinking traits**

Blizzard et al (2015: 92-110) conducted an empirical study to identify design thinking traits within American University students. The data of the study was collected through a survey and the survey questions were based upon two literature reviews conducted by the following authors: Blizzard and Klotz, 2012 and Blizzard, Klotz, Pradham and Dukes, 2012. The data was collected through online survey and phone interviews. The samples were selected through random sampling. The institutions that took part were randomly selected through the list provided by the US National Education Centre for Statistics. The sample was then separated by the number of students enrolled and institution type. 50 institutions agreed to participate in the study with a total of 6772 responses. The 6772 samples were collected in introductory English classes to ensure the survey reached students with different major interests.

Comparing the research methods and strategy used; Blizzard et al (2015) and the research conducted for this PhD were similar. The differences were the sampling technique and the number of participants.

The findings of the study are comparable to the common characteristics of design thinking identified from the research. From Blizzard et al’s study the following traits were identified: feedback seekers, integrative thinking, optimism, experimentalism and collaboration. Table 96 presents their meaning:
<table>
<thead>
<tr>
<th><strong>Design thinking traits</strong></th>
<th><strong>Meaning</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback seekers</td>
<td>They ask questions and look for input from others to make decisions and change directions.</td>
</tr>
<tr>
<td>Integrative thinking</td>
<td>They can analyse at a detailed and holistic level to develop novel solutions.</td>
</tr>
<tr>
<td>Optimism</td>
<td>They don’t back down from challenging problems.</td>
</tr>
<tr>
<td>Experimentalism</td>
<td>They ask questions and take new approaches to problem solving.</td>
</tr>
<tr>
<td>Collaboration</td>
<td>They working with many disciplines and often have experience in more than just one field.</td>
</tr>
</tbody>
</table>

Table 96 Design thinking traits and their meanings (Blizzard et al, 2015: 103)

It must be acknowledged that *optimism* is unique to Blizzard et al’s (2015) design thinking traits. The data collected for the PhD did not provide evidence for a common characteristic similar to *optimism*; the lack of common characteristic similar to *optimism* could be down to the research objectives and questions design. However, other design thinking traits are comparable to the common characteristics identified for this PhD.

‘Feedback seekers’ is comparable to *drivers*. While it has been noted that the meaning behind the trait perhaps has more to do with problem framing; it could be said that ‘looking for input from others to make decisions and change directions’ are similar to the meaning behind *drivers*. With *drivers* having the meaning of the external factors that kick started any project; it could be argued that in the contexts in which they emerged; the two are comparable and are similar to a certain extent as both acknowledge changes in decision making are caused by certain inputs. In the case of Blizzard et al’s trait the changes were caused by the input from others; whereas, *drivers* indicate changes caused by external factors.

‘Integrative thinking’s meaning are comparable to the common characteristics of *impact* as they are both related to creating solutions. With *impact* having the meaning of solving the problem identified using design thinking, *integrative thinking’s* emphasis on developing novel solution made them similar to each other. Additional evidence for *impact* also appeared when Goldschmidt et al (2013: 458) discussed the widen
scope of design application; stating design thinking literature presenting design thinking as a way of generating innovative ideas.

‘Experimentalism’ is comparable with processes (CC) as its meaning emphasised on problem solving with new approaches could be seen as being comparable to some of the evidence identified from the data for processes (CC). Within the common characteristic, the most comparable part within processes (CC) would be prototyping as the trait emphasised on taking new approaches to problem solving. It could be argued the new approaches are most comparable to the prototyping aspect of processes (CC). Further evidence of processes (CC) also appeared when Goldschmidt et al (2013: 458-462) discussed the design activities and sequences used by designers to complete a design project. From the article, sketching was identified as a universally practice activity. Sketching was also identified from the research and was coded as supporting evidence of the common characteristic.

‘Collaboration’ has the emphasis on working with different disciplines; with this emphasis it is most comparable to the common characteristics experts and multidisciplinary.

Despite being identified through a bigger number of samples, it appeared that the Blizzard et al’s (2015) design thinking traits are portrayed in a more focused manner. Here, it means the traits and descriptions are part of the support evidence for the seven common characteristics of design thinking identified through the research of this PhD. Furthermore, the design thinking trait did not appear to explore the problem contexts related to design thinking.

**Berger’s (2009) Glimmer Principles**

Another comparable set of ‘design thinking principles’ to the seven common characteristic identified would be the Glimmer Principles put forward by Berger (2009). Figure 120 shows the Glimmer Principles:
Figure 120 The Glimmer Principles (Berger, 2009: 14)

The Glimmer Principles were developed from the views of design practitioners that Berger interviewed. The Glimmer Principles are made up of four categories: universal, business, social and personal. The categories appeared to be comparable to the seven common characteristic of design thinking.

The first category, universal had the following ‘principles’ filed under it: ask stupid questions, jump fences and make hope visible. According to Berger (2009:14), universal was formed of the three basic design principles. From the description given by the author, and the meaning behind universal: the few design principles that might be used for any purpose; this category appeared to be comparable to processes (CC). The meaning of universal appeared to be closest to the support theme design (verb) within the common characteristic processes (CC). Despite its closeness to the supporting theme, when compared the two; universal appeared to be much more focused as it emphasised heavily on abductive reasoning, questioning (problem framing) and creating
three dimensional objects (design and prototyping). The difference was that processes (CC) and its supporting evidence were developed from the knowledge from academia and practice; therefore, making them accommodating perspectives from both sides to provide a more completed picture.

The second category business appeared to be comparable to ‘design problems’, traditional or non-traditional and impact. The category emphasised on the design principles listed in universal being relevant in the business contexts as they provide ways to deal with pressing challenges and make brands and services come alive in a crowded market place through carefully mapped out consumer experiences (Berger, 2009: 15). The part that was comparable to ‘design problems’, traditional or non-traditional was the usage of the design principles from universal in business contexts. The comparable part to impact was the emphasis on dealing with challenges and making brands and services come alive. This category focused on the non-traditional design problems aspect of the ‘design problems’ common characteristic. From that viewpoint; the two appeared to be the same with different names. However, despite the similarity in that aspect the principle business appeared to incorporate some aspects within the common characteristic of impact with its emphasis on making services and brands come alive. Overall, this principle appeared to be a mix between two common characteristic.

The third category was social, it emphasised on the use of design to address social issues and challenges (Berger, 2009: 15). From the description given, this category appeared to be a direct comparison to the common characteristic ‘design problems’, traditional or non-traditional. When comparing the two, it appeared that social fitted into the social aspects of the non-traditional design problems side of the common characteristic. From the comparisons, the Glimmer Principles appeared to focus on two aspects within the non-traditional design problems evidence of the common characteristic and ignored the traditional design problems. It could be argued that the Glimmer
Principles provided more in depth evidence related to two aspects of non-traditional design problems.

The final category was personal, according to the author it took the discussion from macro (the world at large) and micro (your own life) (Berger, 2009:16). From the meaning given it appeared that this category was unique to the Glimmer Principles. The category was closely related to personal development and design. The seven common characteristics identified from this research did not address the relationship between personal development and design as it was not part of the research aim and objectives.

Overall, comparing the seven common characteristic of design thinking to the Glimmer Principles; only four out of the seven common characteristics appeared to be identified during the comparison. The differences between them appeared to be the Glimmer Principles focused on design application within business and social contexts alongside personal development. The seven common characteristics appeared to paint a more complete picture of what design thinking is, as they were developed using academics and practitioners’ knowledge. It could be said that due to the Glimmer Principles being developed from practitioners’ viewpoints only, its focus on design and business was developed through that.
**Baeck and Gremett’s (2011) core attributes of design thinking**

Baeck and Gremett (2011) put forward the core attributes of design thinking, Table 97 shows these attributes:

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguity</td>
<td>Being comfortable when things are unclear or when you do not know the answer</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Working together across disciplines</td>
</tr>
<tr>
<td>Constructive</td>
<td>Creating new ideas based on old ideas, which can also be the most successful ideas</td>
</tr>
<tr>
<td>Curiosity</td>
<td>Being interested in things you do not understand or perceiving things with fresh eyes</td>
</tr>
<tr>
<td>Empathy</td>
<td>Seeing and understanding things from you customers point of view</td>
</tr>
<tr>
<td>Holistic</td>
<td>Looking at the bigger context for the customer</td>
</tr>
<tr>
<td>Iterative</td>
<td>A cyclical process where improvements are made to a solution or idea regardless of the phase</td>
</tr>
<tr>
<td>Non judgmental</td>
<td>Creating ideas with no judgment towards the idea creator or the idea</td>
</tr>
<tr>
<td>Open mind-set</td>
<td>Embracing design thinking as an approach for an problems regardless of industry of scope</td>
</tr>
</tbody>
</table>

Table 97 Core attributes of design thinking (Baeck et al, 2011)

*Ambiguity* appeared to be similar to the common characteristic of ‘design problems’, traditional or non-traditional as its meanings were describing the types of problems that design thinking addresses. *Ambiguity* appeared to focus on the wicked problem aspect of the supporting evidence for the common characteristic. However, the difference between them was that the common characteristic incorporated a wider range of evidence.
Collaborative appeared to be similar to the common characteristic multidisciplinary. They were similar because their meanings described the disciplines that could be involved when applying design thinking. As a result of their meanings, it could be said that they were the same but named differently.

Constructive appeared to be comparable to the common characteristic impact. While at first glance the attribute could be similar to processes (CC). Constructive’s meanings emphasised on the ‘improvement on future result’. Despite it incorporated phrases such as ‘creating new ideas’ and ‘solution-based approach’ in its meanings, which arguably were closer to the common characteristic processes (CC); the emphasis on constructing and improvement ultimately made it more comparable to impact. When compared to impact, the attribute did not appear as detailed. It would appear that the common characteristic provided more in-depth evidence on the possible impact of design thinking. The attribute only provided a description of what was seen as successful from the authors' viewpoint.

Curiosity’s meanings were related to problem definition and problem shaping. From the meaning given, it appeared that curiosity portrayed the problem framing aspect within the common characteristic processes (CC). It appeared the authors saw problem framing important enough to be a standalone attribute. While problem framing was important from the contexts in which the evidence emerged; the evidence for the common characteristic suggested that it did not need to be on its own. The difference between the two appeared to be the views on its importance.

Analysing the meanings behind empathy, the attribute appeared to be comparable to the common characteristic drivers. The emphasis on user needs and business needs made the two comparable. Similarly to the previous attribute it appeared the authors saw empathy being important enough to be on its own; whereas, the evidence for the common characteristic suggested otherwise.
The attribute *holistic* appeared to be similar to the common characteristic *‘design problems’, traditional or non-traditional*. The meanings behind the attribute further described the contexts that design thinking could be applied in; therefore, making it comparable to the common characteristic. The meanings of the attribute appeared to be more generalised versions of the meanings belonged to *ambiguity*.

The meanings of the attribute *iterative* described design thinking being a non-sequential process; as a result, the meanings make it comparable to the common characteristic *processes (CC)*. The difference between them appeared to be *iterative* meanings gave an overall description of design thinking as a process; whereas, *processes (CC)* gave a detailed view of the processes used when applying design thinking.

The meanings for *non-judgemental* made it comparable to the common characteristic *processes (CC)*. The meanings showed that the attribute appeared to be describing creating ideas and brainstorming aspects within in the common characteristic; therefore, making them comparable to each other.

The attribute *open mind-set’s* meanings appeared to be comparable to the common characteristics *multidisciplinary* and *processes (CC)*. With one meaning emphasised on ‘embracing design thinking as an approach to solve any problem regardless of industry and scope’; this description given matched the meaning behind the common characteristic *multidisciplinary*. With the attribute’s other meaning’s emphasis on ‘embracing a more experimental approach’; it is comparable to the common characteristic *processes (CC)*. The emphasis on ‘experimental approaches’ could be seen as comparable to the prototyping aspect within *processes (CC)*’s supporting evidence.

Overall comparing the attributes of design thinking to the seven common characteristic identified, the attributes appeared to focus on aspects within the supporting evidence identified for the common characteristics. Furthermore two of the attributes (*ambiguity* and *holistic*) appeared to be similar in meaning and it could be seen as a duplication. When
comparing the attributes and common characteristics, only five common characteristic were comparable to the attributes listed they were: drivers, impact, processes, ‘design problems’, traditional or non-traditional and multidisciplinary. None of the attributes were comparable to the common characteristic experts and knowledge.

Other authors’ work that indirectly reveal design thinking’s common characteristics

In addition to the three sets of design thinking traits/principles/attributes; other authors also had indirectly revealed design thinking’s common characteristics.

Brown et al (2015: 58-64)’s Innova School case study provided further evidence for the common characteristic ‘design problems,’ traditional or non-traditional. The evidence gained from the case study was the application of design thinking in the field of education; this added further evidence to design thinking solving non-traditional design problems. The case study also provided further evidence for the common characteristics drivers, experts, impact and processes (CC).

Additional evidence for the common characteristics ‘design problems,’ traditional or non-traditional appeared when Johansson-Skoldberg et al (2013: 128) discussed and reviewed the nature of design thinking as the design consultancy IDEO’s way of working in design.

Further evidence for the common characteristic multidisciplinary also appeared when Joh Johansson-Skoldberg et al (2013: 128-129) discussed the various ways of working with design thinking in the management area using examples from Brown (2009), Martin (2009) and Boland and Collopy (2004).

Compare to the other common characteristics, the evidence for knowledge did not seem to be as easily identified within literature. It appeared that literature written by academics (Baynes, 2013; Cross, 2011 and Ho, 2001) provided a clearer picture of knowledge used with design thinking application. The representation of knowledge was less
clear from practitioner literature. Perhaps this was caused by the practitioners were not in the liberty to discuss them when the literature was being written.

Lawson (2011: 292-300) also appeared to reveal design thinking’s common characteristic when discussed a possible model of designing. Lawson’s proposed the following model for designing shown in Table 98:

<table>
<thead>
<tr>
<th>Stages</th>
<th>Processes within the stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulating</td>
<td>Ways of understanding design problems</td>
</tr>
<tr>
<td></td>
<td>Identifying</td>
</tr>
<tr>
<td></td>
<td>Framing</td>
</tr>
<tr>
<td>Representing</td>
<td>Ways of representing design solutions</td>
</tr>
<tr>
<td></td>
<td>Conversations with representations</td>
</tr>
<tr>
<td></td>
<td>Working with multiple representations</td>
</tr>
<tr>
<td>Moving</td>
<td>Creating solution ideas</td>
</tr>
<tr>
<td></td>
<td>Interpretive and developmental moves</td>
</tr>
<tr>
<td>Bringing problems and solution together</td>
<td>Problem and solution are inseparable</td>
</tr>
<tr>
<td></td>
<td>No clear order of appearance</td>
</tr>
<tr>
<td></td>
<td>Briefing is a continues process</td>
</tr>
<tr>
<td></td>
<td>Parallel lines of thought</td>
</tr>
<tr>
<td>Evaluating</td>
<td>Objective and subjective evaluations</td>
</tr>
<tr>
<td>Reflecting</td>
<td>Suspending judgement</td>
</tr>
<tr>
<td></td>
<td>Reflection in action</td>
</tr>
<tr>
<td></td>
<td>Reflection on action</td>
</tr>
<tr>
<td></td>
<td>Guiding principles</td>
</tr>
<tr>
<td></td>
<td>Collecting precedent or reference</td>
</tr>
</tbody>
</table>

Table 98 Lawson’s model of designing (2011: 292-300)

The stages presented in Lawson’s model appeared to be comparable to the seven common characteristics of design thinking identified the research conducted.

The stage *formulating* and its processes were comparable to the problem framing aspect of the common characteristic *processes* (CC). It appeared the stage *formulating* for Lawson’s model provide an in-depth description of problem framing. Comparing the stage and the common characteristic to each other, the difference between them was that the common characteristic’s evidence was more devised; here, it means it included other processes such as sketching, brainstorming and prototyping. When comparing Lawson’s model it appeared that the first four stages: *formulating, representing, moving and bringing problems*
and solutions together were all detail breakdowns of difference aspects within the common characteristic processes (CC).

The stage representing and its processes were comparable to sketching, prototyping and some of the cognitive evidence within processes (CC). The difference between them was that the stage’s processes’ descriptions highlighted the importance of sketching for designers. The stage also provided evidence and descriptions of how designers interact with their clients, work in teams and communicate. The evidence and descriptions provided by the stage were the differences between the two. In some aspect it could be said the stage also show traits of the common characteristic multidisciplinary; however, it was not comparable as the evidence and descriptions under the processes within the stage were giving description of what designs do rather than the disciplines they could be involved with.

The stages moving and bringing problems and solutions together along with and their processes were comparable to the design (verb) aspect of the common characteristic processes (CC). With the processes under the stage emphasising on moving the design process forward in terms of creating solutions and development of solutions. Those emphasises of design and development made the stages similar to the design (verb) aspect of the common characteristic.

The final two stages of Lawson’s model, evaluating and reflecting appeared to be unique when compared with the common characteristics of design thinking. The two stages emphasised upon the evaluation and reflection side of the design process. The evidence gathered for the common characteristics did not appear to show emphasis towards evaluating and reflecting. The closet common characteristic to the two stages could be impact due to the nature and meaning behind it. However, the evidence coded under impact had little emphasis towards evaluation and reflection aspect within the design process.

From the literature review, it could be said that the common characteristic of design thinking were identified within different types of
literature. The comparison between them suggested that design thinking common characteristics had been presented in different forms. The comparison also identified the different focuses each ‘set’ of design thinking characteristics have because of the origins of the data. Furthermore, it appeared that some authors also indirectly revealed design thinking’s common characteristics in their work. From the comparisons conducted it appeared that the uniqueness of the design thinking common characteristic identified for this PhD was the usage of academics and practitioners knowledge. Here, it means the characteristics were developed using both set of knowledge.

9.3.2. Similarities and differences between academic and practitioner perspectives of design thinking

Similarities and differences between academics and practitioners’ perspectives on design thinking were identified from the thematic analysis. Further evidence for them were identified through content analysis. This section discusses and compares them. Table 99 presents them again:

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences or unique themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design processes</td>
<td>Users/ user centred</td>
</tr>
<tr>
<td>Problem contexts</td>
<td>Creative or creative thinking</td>
</tr>
<tr>
<td>Problem solving</td>
<td>Experts/ multidisciplinary</td>
</tr>
<tr>
<td>Complex or wicked problems</td>
<td>Multidisciplinary</td>
</tr>
<tr>
<td></td>
<td>Divergent</td>
</tr>
<tr>
<td></td>
<td>Questions</td>
</tr>
</tbody>
</table>

Table 99 Similarities and differences between academic and practitioner perspectives on design thinking

**Similarities**

**Design processes**

*Design processes* was the first similarity identified from the two data sets. From the thematic analysis it was identified that both saw *design processes* as the main driver behind design thinking; design thinking cannot be applied without it. While *design processes* was a similarity for both academics and practitioners; they also appeared to have their differences and those were shown in the data. From the academics’
perspectives, the design processes required within design thinking covered a broad spectrum. The spectrum included processes such as design cognition, sketching, problem framing and prototyping. The range of processes identified from the academics data set matched those presented in academic literature.

However, the practitioners’ perspectives were slightly different despite their similarity in the belief that design processes is the main driver behind design thinking. The practitioners’ data showed that practitioners’ views on the design processes used within design thinking appeared to be more focused. Here, it means that the examples provided by the participants focused on the following aspects: user-centred design processes, prototyping, brainstorming and co-design. The focus on these processes matched the findings from practitioner literature, where user involvement, empowering users through prototyping and co-design were a major theme. It could be said when comparing the two data sets; practitioners’ view on design processes appeared to be much more focused. Despite these differences within design processes, it was identified as a similarity between the two because both in principle believed it was needed in order for design thinking to take place.

**Problem contexts**

Problem contexts was the second similarity identified from the data sets. From the thematic analysis both data sets showed problem contexts as an important factor of describing the different fields design thinking can be applied in. When compared to other similarities where there were differences within the two data sets; problem contexts appeared to be a similarity that both parties actually agreed upon.

**Problem solving**

Problem solving was the third similarity identified from the data sets. From the thematic analysis both data sets showed problem solving was seen as the result of employing design thinking. However, the data sets also demonstrated the different viewpoints on problem solving from academics and practitioners. From the academics’ viewpoint problem
solving was not heavily emphasised. This was because from their viewpoint, problem solving was an expected outcome when design thinking had been applied in the suitable manner to the problem. Here, it means using design thinking to solve the problem through the suitable processes, knowledge and expertise. This stance was reflected in academic literature; where design thinking case studies were presented with information listed above. From the practitioners’ viewpoint, the emphasis on problem solving as an impact was far greater than the academics. The data suggested that practitioners portrayed design thinking as a problem solving process for any disciplines that wish to employ it. This emphasis was reflected in practitioner written literature where the emphasis on problem solving appeared to be more important than how to solve the problem. It was identified as a similarity because in principle both parties agreed problem solving is the result of employing design thinking.

**Complex or wicked problems**

Complex or wicked problems was the final similarity identified from the two data sets. From the thematic analysis complex or wicked problems was used by academics and practitioners to describe the type of problems solved by design thinking. Similarly again to the previous similarity, academics and practitioners had different views on the similarity.

From the academics’ data set, complex or wicked problems was used to describe any problems within design; as the term wicked problems was commonly used in academic literature to describe design problems. However from the practitioners’ data set, complex or wicked problems appeared to be used to describe problems given to them by their clients. An example of that would be the service design workshops an interviewee was asked to design and run by a town council in the Netherlands. The interviewee stated that was a complex or wicked problem for the client as they had no previous experience running a service design workshop for its staff. Similar examples were identified from practitioners’ literature. This was identified as a similarity because
both data sets showed complex or wicked problems was used to
describe the problems solved by design thinking despite their
differences.

Differences

Users/ user centred

Users/ user centred was the first difference identified from the data sets. From the academics’ data set and viewpoints, users/ user centred was presented as a requirement when employing design thinking. The academics saw users/ user centred as a way of gathering the required knowledge needed to create suitable solutions to the problems given. When compared to the practitioners’ data set, users/ users centred did not have as much data coded under it in the academics’ data set. This could be down to the sample size. As a result of a bigger data set, there could be more non-coded words leading to a lower number of words coded under the theme.

From the practitioners’ data set, users/ users centred had a different meaning. From the practitioners’ viewpoint users/ user centred was seen as an impact or ‘selling point’ of design thinking application. Practitioners appeared to view user involvement as one of the advantages when employing design thinking. The views recorded in the data set also claimed design thinking enabled its users to be more empathic towards the problem given. This view was reflected in practitioners’ literature; within the literature, user involvement or engagement was portrayed as an impact of design thinking. As a result of using design thinking, organisation can become more empathic. The views recorded from the data set matched the literature findings. The different views between academics and practitioners on users/ user centred could have been caused by the needs of practitioners. Perhaps users/ user centred was portrayed as an impact because user involvement or engagement would make design thinking more attractive to potential clients. In addition to the different meaning showed in the data sets, users/ user centred had a much bigger presence in the
practitioners’ data set. This could be caused by the sample size. The practitioners’ data set was smaller in numbers than the academics’ data set; as a result a bigger percentage of words were coded under the theme.

**Creative or creative thinking**

*Creative or creative thinking* was identified from the two data sets. However, academics and practitioners’ viewpoints on *creative or creative thinking* were different. From the academics’ data set, it appeared that academics saw *creative or creative thinking* as a requirement in order to employ design thinking sufficiently. However, the practitioners’ data set showed that practitioners saw *creative or creative thinking* as an impact of design thinking application. The viewpoints recorded in the practitioners’ data set showed that *creative or creative thinking* had a much heavier emphasis within the data set when compared to the academics’ data set. *Creative or creative thinking* being seen as an impact of design thinking was also reflected in practitioners’ literature as practitioners’ literature claimed that employing design thinking would enable creativity for whoever applied. The difference between the two appeared to be their views on creativity’s role within design thinking.

**Experts/ multidisciplinary**

*Experts/ multidisciplinary* was unique to the academic data set. Despite it appeared to be similar to the practitioner key theme *multidisciplinary*, the two meanings were very different. In the academics' viewpoints employing the suitable experts was vital, as the participation of suitable experts were directly link to creating suitable solutions to the problem given when solving it with design thinking. Therefore from the academics’ viewpoint without the suitable experts, it was not possible to use design thinking to its full potential. The data demonstrated that the academics’ viewpoints believed the suitable experts (regardless of their discipline) were required to create suitable solutions; the relevant experts from different fields would need to take part and be included as part of the
process. The academics’ viewpoint was reflected from the findings from academics’ literature; examples of those viewpoints were identified from case studies used in Chapter 2.4.1 and 2.4.2.

**Multidisciplinary**

*Multidisciplinary* was unique to the practitioners’ data set. As discussed above, *multidisciplinary* was different to a similar key theme identified from the academics’ data set. From the thematic analysis, it appeared that when practitioners mentioned *multidisciplinary* they meant design thinking is a process that anyone can used to solve the problems given to them. From the practitioners’ viewpoints, formal training in design was not a necessary requirement for the successful employment of design thinking. The literature findings matched the viewpoints presented in the data set. Examples of that viewpoint were identified from literature written by design practitioners and commentators (Brown, 2009; Brown and Martin, 2015; Martin, 2009; Berger, 2009). An example of that would be Brown’s (2009: 3) emphasis on design thinking being an approach that everyone can use. It could be argued that the reasons behind the practitioners’ viewpoints being different to the academic one was caused by the demands and needs of practitioners when using or ‘selling design thinking.’

**Divergent**

*Divergent* was unique from the academics’ data set. From the academics’ viewpoints divergent was seen as an impact of design thinking. When compared to *creative or creative thinking*, the difference between them was *divergent* was the result of creatively applying design thinking to solve the problem given. Examples of that from literature were identified from the case studies used in Chapter 2.4.1 and 2.4.2.
Questions

Questions was unique to the practitioners’ data set. From the thematic analysis, the data indicated practitioners used questions as a way of reframing the problems given. Using questions as a way of problem framing could be identified from practitioners’ literature, an example of that was ‘ask stupid questions’ from Berger’s (2009) Glimmer Principles as discussed in the previous section of this Chapter.

9.4. Discussion of feedback from the validation studies

The participants from the validation studies identified areas of concern related to the research. From the academic viewpoint they were:

- Range of literature reviewed
- Refinement of three common characteristics (impact, experts and knowledge)
- Bias towards industrial/ product design
- Limitation of the study caused by bias towards one design discipline
- Area of application for the model
- What is the unique about the model and its contribution to knowledge.

From the practitioner viewpoint they were:

- Bias towards one discipline
- The common characteristics of design thinking do not represent all aspects of design
- Design thinking’s modes of expression were not clearly communicated; possible further development required.
- Bias towards one discipline in case study analysis
- Lack of ‘mature objects’ represented in the research
- The model should not be used as a blueprint of design education
- The model does not represent the emotional side of design
- The model was unintuitive.

This section discusses and reflects upon these areas of concern.

9.4.1. Academic feedback discussion and findings

Range of literature reviewed

From the academic validation the participants highlighted the range of literature reviewed as a concern. They raised the question if literature from other fields related to design thinking was reviewed. This was a valid concern; literature from other field possibly related to design thinking was not reviewed. An expanded range of literature from related fields could provide further richness towards the findings of the research and the possibility of identifying other common characteristics.

Refinement of common characteristics (experts, impact and knowledge)

The academic participants highlighted three common characteristics would benefit from further refinement, they were: experts, impact and knowledge. The participants believed experts and knowledge were similar and closely related that they should be merged together. One suggested the two should be combined into ‘expertise’. The participants also suggested refinement and further development for the common characteristic of impact. They believed impact with its current form was not a sufficient way of describing and portraying the meaning behind the common characteristic. They suggested a scale should be developed to show impact over time.

Reflecting upon the feedback; combining the common characteristics experts and knowledge would be beneficial; as a more distinctive common characteristic that would be easier to understand can be developed. Impact would also benefit from further development
following the suggestions made; however, this would depend on the case studies available.

**Bias towards industrial/ product design**

One of the main concerns from the participants’ viewpoint was the bias towards industrial/ product design. The bias towards one discipline was a limitation of the research. The limitations will be discussed in the following section of this chapter. To further better the understanding of design thinking,

The use of industrial/ product design case study was because of the examples available from literature and data gathering plus the researcher’s background. From literature examples of design thinking application were often demonstrated through the discipline of product design. As a result of the examples available, majority of the case studies featured in the research were from industrial/ product design. In addition, from the data gathering with the exception of one case study, all were from industrial/ product design because of the samples available when the research was conducted. Industrial/ product design was also the discipline the researcher has the most experience in; therefore, it made sense to use that to discover how design thinking is understood by academics and practitioners.

For future reference, more views and knowledge from other design disciplines will be included whenever possible.

**Limitation of the study caused by bias towards one design discipline**

Using mainly industrial/ product design case studies was a limiting factor within the research. Reflecting upon this limitation; it would be beneficial to include case studies from the field of service design and graphic design as those two fields has the potential of yielding useable examples. Should the opportunities arise in the future to continue the research; inclusion of additional case studies from other fields will be factor in.
**Areas of application for the model**

The participant questioned if the model can be applied outside the discipline of industrial/product design. The answer to that question is yes. The model developed from the research findings was the first ‘version’ of the model; here, it means the model was developed from the findings and used product/industrial case studies to communicate what design thinking is. If the opportunity arises in the future the aim is to incorporate more disciplines into the model and further develop it.

**What is unique about the model and what is its contribution to knowledge?**

The model is unique in the sense that it is a qualitative data driven model developed from data provided by academic and practitioner. Furthermore, it incorporated design thinking’s modes of expression, which are: graphicacy, language, numeracy, physicality and processes (ME). The identification of the modes of expression furthers the understanding of design thinking by communicating how the different aspects are expressed. The contribution to knowledge of this PhD is the following:

- A qualitative data driven model of design thinking as a platform to further the understanding of design thinking
- Identification and clarification of design thinking’s modes of expression.

9.4.2. **Practitioner feedback discussion**

**Bias towards one discipline**

The practitioners also highlighted the bias towards one discipline as a concern. The bias towards one discipline was a limitation of the research. Additional disciplines will be included in the future wherever possible.
The common characteristics of design thinking do not represent all aspect of design

It has been noted there are possible limitation on the common characteristics due to the findings that they developed from. This was likely to have been caused by the bias towards one design discipline. However, it must be noted that these common characteristics were developed with the aim to further the understanding of design thinking. Therefore, they were created to demonstrate the most common occurring aspects within design thinking. Reflecting upon this limitation; to make the common characteristics’ coverage better, the inclusion of additional design disciplines in future studies will provide more knowledge to counter this limitation.

Design thinking’s modes of expression were not clearly communicated; possible further development required.

The modes of expression identified were communicated through examples. At this stage the researcher believes they are sufficient. The modes of expression will need further development as the research only managed to identify them. The relationship between design thinking and its modes of expression requires much more in depth research. Further research conducted on the modes of expression will address this issue.

Bias towards one discipline in case study analysis

Again it has been noted that the heavy usage of industrial/ product design case studies was a limitation within the research conducted. The issue will be resolved by the incorporation of case studies from different design disciplines.

Lack of ‘mature objects’ represented in the research

The lack of ‘mature objects’ for example products such as chairs and kitchenware was a concern for the practitioners. They believed ‘mature objects’ could be created using design thinking and the problems encounter when creating them could be just as complex. The lack of ‘mature objects' representation in the research was not by choice. With
the case study analysis; the pool of samples did not have any projects that fell into the ‘mature objects’ category. As a result the case study analysis did not feature any of those. To address this potential limitation in the future, additional questions addressing ‘mature objects’ examples within design thinking could be added to gather data on the issue highlighted.

**The model should not be used as a blueprint of design education**

There was no intention at all to use the design thinking model as a blueprint of design education. The model was created as a way to communicate the findings of the research and help further the understanding of design thinking. It was never the research’s intention to create any design education blueprint.

**The model does not represent the emotional side of design**

The lack representation on design emotions appeared to be a weakness of the model identified by the participants. The model did not represent design emotions because of the data used to develop the model. From the additional literature review conducted earlier in this Chapter (9.3.1), Blizzard et al (2015) identified design emotions as one of the traits of design thinking. With the identification of that in Blizzard et al’s (2015) design thinking traits; design emotion appeared to be an area that should be added to the model in the future. To address that new research questions related to the topic are required.

**The model was unintuitive**

The model was presented the way it was because its function was to communicate the findings of the research. While it would have been beneficial to add more details into it for the reader; too much information could have caused further confusion. Therefore the decision was made to use the amount of information to present the research findings. The feedback regarding its intuitiveness has been noted; should the opportunity arises, the graphics of the model would be redesigned or further developed by a professional graphic designer.
9.5. Potential usage of the consensus model

From the research findings, a qualitative data driven consensus model of design thinking was developed. The validation studies highlighted the drawbacks and weaknesses of the model; those will be addressed should the opportunities arise in the future.

Despite its drawbacks, the model still has the potential to be used in the following ways. The first potential usage of the model could be using it as the basis for the development of a design thinking module. The design of the teaching materials could use the seven common characteristics as a starting point and develop from there. It could be argued that potential use of the model would be similar to the Open University level 1 module 'Design Thinking: Creativity for the 21st Century' presented by Lloyd (2011: 214-226). Comparing Lloyd’s four key concepts: problem framing, productive dialogue, quiet design and using expertise that formed the basis of the module; it could be argued that they are similar to two of the common characteristics that formed the basis of the model. Problem framing, productive dialogue and quiet design appeared to be comparable to the common characteristic processes from the model. Using expertise was similar to the common characteristic experts. The Open University module appeared to be focusing on two of the common characteristics identified from the research; the difference between the two appeared to be the inclusion and exclusion of the different aspects of design thinking.

Another potential usage for the model could be to use it as a guideline of how to apply design thinking sufficiently. To do so further development of the model will be needed. The areas that would be needed further development in addition to the common characteristics would be design thinking’s modes of expression. The research conducted managed to identify them and matched them to the common characteristics; however, to truly understand their relationship with design thinking and its common characteristics further research will be required. In addition, the potential application sequence would also need to be further developed with data from more design disciplines.
Finally another potential use for the model could be using it as the starting point to develop a design thinking audit tool. This will be discussed further in the next Chapter.

9.6. Limitations of the research and potential improvements for future work

This section discusses the following limitations of the research:

- Sample size of the main study
- Bias towards industrial/ product design
- Failure to address the emotional aspect of design
- Lack of mature objects in the case studies analysed
- A qualitative data driven model of design thinking

**Samples size of the main study**

One of the limitations of the research was the sample size of the main study. In total 56 participants took part (43 survey responses and 13 interviews), while this was sufficient enough from the data generation and quality of data viewpoint. When compared to the sample size that Blizzard et al (2015) identified their design thinking traits from, it showed that the sample size could have benefited being bigger. Furthermore, another limitation of the sample size was the unbalance between academic and practitioner participants. With the academics outnumbering practitioners 2 to 1, the academic data sets were bigger; the research would have benefited from practitioners data sets of similar size. The amount of time allowed to conduct the research also played a part in the sample size used for the research. Should the data gathering period be longer than the given six months, sample size could increase as well as a better balance between academics and practitioners.
**Bias towards industrial/product design**

One of the major limitations of the research was the bias towards industrial/product design. This bias was caused by a number of factors; one of the factors was the case studies samples available when the research took place. The heavy usage of industrial/product design case study within the research was also caused by some of the initial literature review findings; where academics and practitioners used industrial/product design case studies to explain design thinking application. As a result of those case studies presented in literature, the point of departure for the research was developed through findings from industrial/product design case studies. Another factor of bias towards one discipline was caused by the case studies samples available when conducting the case study analysis part of the research. Finally another factor contributed towards the bias was the researcher’s education background and personal experience in industrial/product design.

This bias has been acknowledged and to address the limitation in the future more discipline will need to be included in the research.

**Failure to address the emotional aspect of design**

A limitation identified from the validation studies was the failure to address the emotional aspect of design. The failure to address the emotional aspect of design could have been caused by a number of factors. The first factor was the data generated from the research conducted. As a result of the research questions set, the research instrument was designed according to the need of answering them. Therefore, without any of the research questions related to the emotional aspect of design, it was not addressed within the research.

Another factor that caused this failure was how the design thinking model was constructed. Due to the structure of the model and the breakdown of design thinking via the common characteristics; the emotional aspect of design was not accounted for. Furthermore from the analysis conducted, did not appear to identify any evidence related to the emotional aspect of design.
From the validation studies and additional literature reviewed, the emotional aspect of design appeared to be an aspect or common characteristic that need to be included. To address this limitation, future research will add the related research questions.

**Lack of mature objects in the case studies analysed**

Another limitation identified from the validation studies was the lack of ‘mature objects’ represented in the research. This limitation was caused by the samples available when the case study analysis was being conducted. From the feedback gained during the validation studies, the practitioners saw this as an area worth exploring. To address this limitation research question related to the topic will need to be added to the research instrument in the future.

**A qualitative data driven model of design thinking**

While the development of the design thinking model from the findings addressed one of the research questions. The model could also be seen as a limitation of the research. While the model is a good starting point to further the understanding of design thinking, it also has its drawbacks. One of the limitations of the model was the bias towards product/industrial design; as a result of the sample and data available. The model needs further developing in order represents more disciplines that employ design thinking. Another limitation of the model was it being intuitive; this could be resolved by the incorporation of additional design disciplines and redevelopment of the visuals.

### 9.7. Summary of Chapter 9

This Chapter started with the discussion of reliability and validity of the data collection methods and research strategy. In that discussion, the strengths and weaknesses of the evidence for the common characteristics generated by three different data collection methods were compared. From the comparison, it was established that interviews generated the most in-depth data, survey generated data with greater diversity and case study analysis produced data in their natural environment. Out of the seven common
characteristics identified, six of them had majority of their evidence generated by interviews and online surveys, those were: *drivers, experts, impact, processes, ‘design problems’ traditional or non-traditional* and *multidisciplinary*. For those six common characteristics the case study analysis evidence ensured the reliability of the evidence. *Knowledge* was the exception with weak evidence from interviews and online surveys. However, case study analysis provided the evidence required to confirm knowledge as a common characteristic.

The discussion also compared the seven common characteristics to additional literature. The comparison showed that the common characteristics were represented in the works of academics and practitioners but in different forms. It also highlighted the uniqueness of the seven common characteristics as they were developed from academics and practitioners knowledge. Finally the comparison identified the emotional aspect of design to be a missing representation within the common characteristics identified.

The Chapter also discussed the similarities and differences between academics and practitioners viewpoints of design thinking. The differences between the two appeared to be how the different aspects within design thinking were being portrayed.

Finally the Chapter discussed the feedback gathered through the validation studies, the potential usage of the design thinking model and limitation of the research.
Chapter 10 - Conclusion and future work
10.1. Introduction

This Chapter concludes the research conducted for this PhD. The Chapter presents the conclusion of the research, if the research achieved the aim and objectives set via answering the research questions, its contribution to knowledge and future work.

10.2. Conclusion of the research

To conclude the PhD established the following:

- Design thinking's 7 common characteristics. They are drivers, experts, impact, processes (CC), 'design problems', traditional or non-traditional, multidisciplinary and knowledge. They were identified from literature review, data gathered through interviews, online survey and case study analysis.

- Design thinking's modes of expression. They are graphacy, language, numeracy, physicality and processes (ME). They were identified through content analysis from the data gathered via interviews, online survey and case study analysis.

- Through the identification of design thinking's modes of expression, it was established that design thinking was taught in an unknowing manner in design education. As a result, those who have not undertaken formal design education would be at a disadvantage when expressing the following: graphacy, physicality and processes (ME).

- The difference between academic and practitioner viewpoints on design thinking were the contexts in which they operate in and focus on certain aspects within design thinking. Referring back to the research findings presented Chapter 5 and 9, academics and practitioners had similar viewpoints on the following aspects of design thinking: design processes, problem solving, problem contexts and complex or wicked problems. Their differences in viewpoints on the following aspects of design thinking: users/
centred, creative or creative thinking, experts/ multidisciplinary, divergent and questions.

- From the findings a qualitative data driven model of design thinking was developed. The model incorporated a generic data driven consensus definition of design thinking, design thinking’s 7 common characteristics, design thinking’s mode of expression and a potential application sequence identified from case study analysis.

### 10.3. Did the research achieved the aim and objectives set?

This section reviews if the aim and objectives set were achieved and review how well the research questions were answered.

The aim of the research was:

- The aim of this research is to identify the possible knowledge gap that exists between academic and practitioner understanding and application of design thinking to generate a consensus-driven definition.

From the research the possible knowledge gap that exists between academics and practitioners' understanding and application of design thinking was identified. The research findings showed practitioners focused on a selected number of aspects within design thinking as discussed in the previous section. Practitioners’ viewpoints focused on user engagement and involvement, problem framing, and solving problems in other disciplines such as social and business. As a result of the focus the practitioners’ understanding and applications of design thinking had a heavy emphasis on creating innovation through design thinking.

From the academics’ viewpoints design thinking was be more than just a set of problem solving processes with a focus on user engagement and involvement that can be applied to other disciplines. The findings showed academics believed design thinking was a way to understand how designers function and further the understanding of design cognition.
The different focuses and emphasis on aspects within design thinking was the knowledge that exists between academics and practitioners.

Using the findings from thematic analysis, content analysis (Chapter 5) and case study analysis (Chapter 6); a consensus driven definition was developed (Chapter 7):

*Design thinking is a collection of designly approaches and methods of problem solving that can be used in any context to generate solutions creatively by employing the suitable expertise and knowledge.*

The aim of the research was achieved by the identification of the knowledge gap and development of a data driven consensus definition of design thinking.

The first research objective was:

- Articulate the meanings and understanding of design thinking since the 1960s

The research findings indicated that the articulation of design thinking has changed little since the 1960s; however, it is the contexts in which design thinking being applied in has dramatically transformed (Chapter 2). This conclusion was reached by answering the research questions under the objective. The following research questions belonged to the research objective:

1. Where was the concept of design thinking first articulated?
2. Has the meaning of design thinking changed since the 1960s?
3. Do academic and practitioner interpret design thinking differently?
4. Can a ‘generic’ design thinking mode be created from academic and practitioner interpretations?

Research Question 1 was answered via the initial literature review (Chapter 2). The initial literature review identified design thinking as it is understood today was first articulated in the 1960s. The evidence of that was presented in the works of Archer (1965 & 1967), Jones (1963) and Luckman (1967).
From the initial literature review, tracing the origins of the concept abductive reasoning, the first articulation of design thinking was in the 1860s when Pierce put forward the concept of methodology of science.

Research question 2 was answered via the initial literature review (Chapter 2). The initial literature review reviewed academics and practitioners’ literature on design thinking from 1960s to present. The findings revealed in Chapter 2.3 and 2.4 showed that the articulation of design thinking since the 1960s has changed little; however, it is the contexts in which it is being applied in that have dramatically transformed.

Research question 3 was answered via the initial literature review, interviews, online survey and case study analysis. The findings of the research indicated that practitioners interpret a number of design thinking aspects differently to academics discussed in Chapter 9.3.2. An example of that was the interpretation of creativity; from the practice viewpoints it was an impact of using design thinking. But from the academia viewpoints it was a requirement to apply design thinking effectively.

Research question 4 was answered by the development of a qualitative data drive model of design thinking from the research findings (Chapter 2, 5, 6 and 7).

The second research objective was:

- Clarify if design thinking is thinking done by designers.

Through the identification of design thinking’s modes of expression the findings revealed in Chapter 5.4.5 and 5.4.6, the findings clarified design thinking is thinking done by designers. The evidence behind that conclusion came from the analysis conducted on taught design modules at Loughborough University, design thinking’s common characteristics and modes of expression. From the analysis each taught module was matched with a number of common characteristics and modes of expression. That finding indicated design thinking is thinking done by designers as those modes of expressions and common characteristics was taught in design education.
Under research objective 2 were the following research questions:

5. How is design thinking expressed?

6. Is design thinking taught as an integrated aspect knowingly or unknowingly, of design education?

7. Are those who have not undertaken formal design education at a disadvantage when expressing design thinking?

Research question 5 was answered via the identification of design thinking’s modes of expression through content analysis (Chapter 5.4.5, 5.4.6 and 6). While the modes of expression were identified and explain within the contexts of the research; it must be noted that to fully understand design thinking’s modes of expressions further research on the area will be needed.

Research question 6 was answered via content analysis conducted alongside the identification of design thinking’s modes of expression. The findings presented in Chapter 5.4.6 and 6 indicated that design thinking was taught in an unknowing manner within design education.

Research question 7 was answered from the findings of the content analysis conducted presented in Chapter 5.4.5, 5.4.6 and 6. As a result of identifying design thinking being taught as an unknown manner, the conclusion for research question 7 was that those who have not taken formal design education would be at a disadvantage when expressing the following modes of expression: graphicy, physicality and processes (ME).

The third research objective was:

- Explore the relationship between academic and practitioner application and understanding of design thinking.

The third research objective was partially achieved by the identification of design thinking common characteristic and modes of expression (Chapter 2 and 5). Through the identification the different focus between the two sets of viewpoints were identified. The common characteristics and modes of expression suggested there are share aspects between the two. The thematic and content analysis conducted also indicated that practitioner
focused on certain aspects of design thinking such as user engagement, creativity as an impact and innovation creation. Academic appeared to have no such focus. The research objective would have benefited from more time being allowed when conducting the research.

Under research objective 3 were the following research questions:

8. Does design thinking as incorporated in designing within academia match academic articulation of the concept?

9. Does design thinking as incorporated in designing within practice match practitioner articulation of the concept?

Research question 8 was partially answered via the findings from the literature review, content analysis and case study analysis (Chapter 2, 5 and 6). The findings indicated that designing in product design within academia appeared to match the academic articulation of the concept. The research question would have benefited from more case study examples from other discipline of design to have a better variety of data to answer the research question.

Research question 9 was partially answered in the same way as research question 8. The findings indicated that designing in product design and service design within practice appeared to match the practice articulation of the concept. A wider range of design discipline would have help to answer this research question better.

10.4. Contribution to knowledge

This PhD’s contributions to knowledge are the following:

- Identification and development of design thinking’s seven common characteristics. The seven common characteristics of design thinking were developed from qualitative data gathered from academics and practitioners. The findings from the literature review suggested that there were common characteristics shared between the two parties. The evidence showed those were: drivers, experts, impact and processes (CC). These formed the basis of the research
instrument and pilot studies. Through the pilot studies, an additional common characterise was identified and it was: ‘design problems,’ traditional or non-traditional. The research then moved forward to data gathering to gather supporting evidence for the common characteristics. The data were gathered using interviews and online survey. Through thematic analysis; two additional common characteristics were identified they were: multidisciplinary and knowledge. Through content analysis, the research was able to identified rich qualitative supporting evidence for the seven common characteristics hence providing a detail description how to identify the common characteristics. To ensure reliability on the data, case study analysis was conducted. The seven common characteristics were identified in the case studies and the case study analysis also provided further supporting evidence of them.

- Identification of design thinking’s modes of expression. The initial literature review findings suggested that design thinking could be expressed in a number of ways. From the evidence a number of ways to express design thinking emerged. Using the findings as guidance, an additional literature review was conducted to identify further evidence. Using the evidence identified the following modes of expressions were developed: graphicity, language, numeracy, physicality and processes (ME). Content analysis was conducted to identify supporting evidence of the modes of expressions from interview and online survey data. From the data, the research was able to shed light on how design thinking is expressed by showing how the different elements within the common characteristics can be expressed. Data from the case study analysis also helped to provide further evidence on the modes of expressions and how they were used within different design projects.

- Identified that design thinking is taught in an unknowing manner within design education. This conclusion was developed from content analysis conducted on Loughborough University’s taught undergraduate module lists. The analysis conducted on the module
descriptions, expected output and learnings showed design thinking was being taught in an unknown manner. As a result of that those who have not had formal design education would be at a disadvantage when applying the following aspects: graphicy, physicality and processes (ME).

- The development of a qualitative data driven model of design thinking as a platform to further the understanding of design thinking. The model is unique in the sense that it was developed using academics and practitioners understanding of design thinking. It is a platform that incorporates all of the research findings and presents them as a potential way for design thinking application.

10.5. Future work

Should the opportunity arise to conduct further research on the topic; the following are areas of interest:

- Continued development and refinement of the design thinking model

- Using the model as the starting point to develop a design thinking audit tool for those who wish to apply design thinking.

- Explore the relationship between design thinking’s modes of expression, design thinking and design education.

- Create an online design thinking resource base using the findings from the PhD as a starting point.

Continued development and refinement of the design thinking model

One of the possible areas of future work would be the continue development of the model. As discussed in Chapter 8.3, 8.4, 9.5 and 9.6 the existing model has its limitations in terms of bias towards one design discipline, common characteristics incorporated would benefit further development, modes of expressions required further development and address the lack of representation of the emotional aspects within design. Further research
conducted using the limitations and weaknesses identified as a starting point could lead to further development and addressing the issues.

*Development of a design thinking audit tool for those who wish to apply design thinking*

The development of a design thinking audit tool could also be an area of potential future work. Using the seven common characteristics identified and model as a starting point; design a research project to identify more possible common characteristics and design thinking knowledge from other disciplines. The data would be gathered from academics and practitioners with the aim of a bigger sample size. The audit tool would be developed from the findings gathered. Should the audit tool be developed, further research projects could be conducted bi-annually to update the tool.

*Explore the relationship between design thinking’s modes of expression, design thinking and design education*

Design thinking’s modes of expression were identified from the research conducted. However, the research only managed to identify and matched them to the common characteristics identified. It cannot be said the research findings provided a definitive understanding of the relationship between the modes of expression and design thinking. Exploring the relationship itself would be a research project on its own. Therefore, this area of interest has the potential to be a PhD or Post-Doc research project. In depth exploration of the topic is needed to truly understand the relationship. In addition, the research project could also continue the development of the modes of expression.

*Create an online design thinking resource*

Another potential area of future work could be the creation of an online design thinking resource. To start with the design thinking model from this project would need further development to address its limitation and weaknesses. With the model refined, it would then become the centre of this online resource showing how to apply design thinking in different contexts. Should this be taken forward, the online resource would need to be updated
regularly. One solution towards maintain the resource would be partnering with Universities and design consultancy; using their knowledge to maintain it.
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PENDLEBURY, E. 2014 Lumo Portfolio. Final Year Design Report Portfolio (BA)., Loughborough University


Appendices

Appendix 1 – PGR Training record
<table>
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<th>Sessions</th>
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Appendix 2 – Full methodology diagram
The academic and commercial perspectives of design thinking

1. Literature review

- Drivers, Expects, Impact & Processes
- 4 common characteristics of design thinking

Methodology diagram 3rd October 2014 (updated)

Overall aim

- The aim of the research is to identify the possible relationship between academic and practitioners' understanding and application of design thinking, therefore articulate the relationship between the two and define what design thinking is.

Research Area 1:
What is the current understanding of design thinking?

Research Question 1:

- Where was the concept of design thinking first articulated?

Research Question 2:

- Has the meaning of design thinking changed since the 1960s?

Data collection

- Data sets 1: 60 participants (8 academics, 7 practitioners)
- Data sets 2: 50 participants (10 academics, 10 practitioners)
Validation study design (presentation and questions)

- Presenting and discussion with academics
- Presenting and discussion with practitioners

- Question set 1: methodology
- Question set 2: the qualitative data driven model of design thinking
- Question set 3: design thinking’s models of expression

- Discussion and comparison of the research outcomes in the context of current literature
### What is design thinking?

*a brief overview of its origins, literature and application*

_A Chan_

_January 2013_

_Loughborough University_

### Today’s presentation

*Origins of design thinking*

*Overview of design thinking literature from the 60s*

*Case studies*

### Case studies

Throughout the presentation there will be a portfolio of case studies that showcase claims of design thinking being applied in practice.

### Common factors

These case studies share the following 4 common factors:

- 'Game changer'
- Experts’ participation
- Competitive advantage
- Revolutionised the product

### 1860s

American philosopher Charles Sander Peirce presented the methodology of science.

*Abduction, deduction and induction are not three different forms of arguments instead they are phases of the methodology of science.*

### 1865

- American philosopher Charles Sander Peirce presented the methodology of science.

*Abduction, deduction and induction are not three different forms of arguments instead they are phases of the methodology of science.*
1960s

1963

"(...) Imagination does not work well unless it is free to
alternate between all aspects of the problem, in any order
and at any time, whereas logical analysis breaks down if
there is the least departure from a systematic step-by-step
sequence. (...)"

any design methods must permit both kinds of thought to
proceed together if any progress is to be made.

J. Christopher Jones

1965

"It has also been argued that the process of designing
involves analytical, and creative, objective and subjective
phases. The practice of design is thus a very complicated
business. Involving contrasting skills and a wide field of
disciplines, it has always required an odd kind of hybrid to
carry it out successfully."

Bruce Archer

1967

"The process of design is the translation of information in the
form of requirements, constraints, and experience into
potential solutions which are considered by the designer to
meet required performance characteristics."

John Luckman

Case study 1: The King's Fund
Hospital Bed, 1963 - 1975

GAME CHANGER

NHS cost cutting and effort to
standardise hospital equipment.

60%

EXPERT PARTICIPATION

A multidisciplinary team of
nursing staff, engineers and
designers.

85%

Up to 85% of UK hospitals still use
the bed design (RCA, 2012)

REVOLUTION

COMPETITIVE ADVANTAGE

Introduced the evidence-
based research process for
product design
1970s

/twenty-seven/ 1973

"There is no definitive formulation of a wicked problem."
Hans J. Kilfeather and Melvin M. Webber

1976

"(...) the primary objective of designing is to realize a particular case or design. Both require deduction, the a a priori formative role of mathematical reasoning, for analytical purposes. Yet science must employ inductive reasoning in order to generalize, and design must use productive inference so as to particularize.

Thus production creates; deduction predicts; induction evaluates."
Lionel March

1979

"(...) humans beings have an innate capacity for cognitive modeling, and its expression through sketching, drawing, construction, acting out and so on (...) Thus design activity is not only a distinctive process, comparable with but different from scientific and scholarly processes, but also operates through a medium, call modeling..."
Bruce Archer

1979

"(...) a methodology which does not depend on the completion of problem analysis before synthesis can begin."
Bryan R. Lawson

1980s
1981

"Design, like Science, is a way of looking at the world and imposing structure upon it. Design, then, can extend to any phenomenon to which we wish to pay designerly attention, just as Science can extend to any phenomenon to which we wish to pay scientific attention."

Bruce Archer

1982

"In order to cope with ill-defined problems, the designer has to learn to have the self-confidence to define, redefine and change the problem-as-given in the light of the solution that emerges from his mind and hand."

Nigel Goss

1982

"The way designers work may be inexplicable, not for some sort of romantic or mystical reason, but simply because these processes lie outside the bounds of verbal discourse: they are literally inexpressible in linguistic forms."

Janet Darcy

Case study 2: Hydro-pneumatic suspension for Brabham F1 Team, 1981

1990s

GAME CHANGER
P1 introduced new aero rules for the 1981 season

EXPERT PARTICIPATION
Gordon Murray and his team of engineers

4 x P1
1 x WDC

Nelson Piquet won the 1981 driver's world title (Alfa F1, 1981)

COMPETITIVE ADVANTAGE
Set the examples of exploiting aerodynamics in F1 rules

REVOLUTION

1990

“Design thinking as comprising abilities of resolving ill-defined problems, adopting solution-focused cognitive strategies, employing abductive or oppositional thinking and using non-verbal modeling media.”

Nigel Cross

1993

“Abductive reasoning as the necessary logic of design – the necessary step from function to form.”

Norbert Rozenberg

Case study 3: Alessi Family follows Function range, 1991

GAME CHANGER
Human emotions and transitional objects.

EXPERT PARTICIPATION
Consumer lead culture experts and architects.

Competitive advantage
Alessi achieved double digit growth in the 90s.

Household products can be functional and emotional.

2000s

2009

“An approach to innovation that is powerful, effective, and broadly accessible, that can be integrated into all aspects of business and society, and that individual and teams can use to generate breakthrough ideas that are implemented and that therefore have an impact.”

Tin Can Brown
2009

The term “Design Thinking” originated in an academic context from research into the cognition peculiar to designers. In the commercial world, it has become an easily branded term phrase that designers have been quick to use to place themselves at the center of the innovation trend.

Anne Burdick

Case study 4: Nintendo Wii console, 2005

GAME CHANGER
Motionsensor technology, Microsoft and Sony overhauling Nintendo.

EXPERT PARTICIPATION
Target customers writing the brief with Nintendo designers and testing.

165%

Nintendo share price increased, Microsoft and Sony price war.

COMPETITIVE ADVANTAGE

CHANGE

REVOLUTION

Case study 5: IDEO TSA Security Checkpoint Evolution, 2009

GAME CHANGER
New ways of avoiding detection during airport security checks.

EXPERT PARTICIPATION
Amile staff, passengers, TSA officials and IDEO designers.

Reflect out across the USA since worldwide adoption.

COMPETITIVE ADVANTAGE

New TSA training programme.

REVOLUTION

2010s
2010

In summary, we can state that Brown’s (2009) ‘new’ design thinking approach proceeds a pre-scriptive or even scientistic view, which is ultimately formulated at a rather low resolution level. The instructions are not empirically nor theoretically supported; they are a generalization of his own experience packed in a kind of popularized management problem solving approach.

Norbert Kroosenburg

2010

I think of design thinking as combining the best of analytical thinking — that is, thinking based on declarative logic whose purpose is to declare a proposition to be true or false — and intuitive thinking, which is knowing without reasoning. Analytical thinking attempts to prove that something is indubitably true. Intuitive thinking is about imagining a future that cannot be proven in advance.

Roger Martin

2010

Design thinking is a public relations term for good, old fashioned creative thinking.

Don Norman

2011

Design thinking is a failed experiment, so what’s next?

Bruce Hockenm

The end

Thank you for your time. The interview will begin shortly and your responses will be recorded.
Appendix 4 – Research instrument presentation, April 2013

Inside this presentation...
Origins of design thinking
Overview of design thinking literature from the 60's
A portfolio of case studies

Case studies
Throughout the presentation there will be a portfolio of case studies that showcase claims of design thinking being applied in practice.

Case studies - common characteristics
These case studies share at least 4 common characteristics:
- Drivers
- Experts
- A viewpoint
- Processes

1860s
Origins of design thinking, 1860s

Abduction, deduction and induction are not three different forms of argument, but rather phases of the methodology of science.

Charles Sanders Peirce, 1865
**Abduction, Deduction and Induction**

**Abductive reasoning:**
Creates a hypothesis that may or may not be true and which may require further work to verify.

**Deductive reasoning:**
Starts with an assumed hypothesis or theory and deduces specific instances to test if the hypothesis is true.

**Inductive reasoning:**
Starting from specific case or cases and deriving a generalization, or making an inference from observation in order to make generalizations.

---

**Events in the 1960s**

**Design Methods Movement**

**Defining design as a discipline**

Emergence of design thinking as it is understood today.

---

**Literature from the 1960s**

```
1. The emergence of design as a discipline
2. The emergence of design as a profession
3. The emergence of design as a profession
```

---

**Case study: The King’s Fund Hospital Bed 1963 - 1975**

**Drivers:**

- Web use; cutting edge technology
- Interdisciplinary involvement

**Experts:**

- Multi-disciplinary team of designers and healthcare professionals

**Processes:**

- Introduced the evidence-based research approach to product design
- Successfully tested and implemented

**Impact:**

- Up to 80% of patients used the new design [Hoskins, 2010]
**1970s**

- Literature from the 1970s
  - There is no definitive formula for an applied product.
  - Event: The Institute of Design at Illinois - 1960s
  - The design activity is not only a solution process, it is a process that will define the work that is to be done.
    - Source: Storck, 1965
  - A methodology which does not depend on the empiricism of problem solving, allows synthesis on deeper levels.
    - Source: B. Jacobs, 1970

- Events in the 1970s
  - Continue to define design as a discipline.
  - Design as the third area of education.
  - Empirical evidence of the existence of design thinking.

**1980s**

- Literature from the 1980s
  - Explorations of what is design knowledge.
  - Concepts of design strategy and design theory.
  - General consensus on the existence of design thinking.

- Events in the 1980s
  - Exploration of the role of design in society.
  - Conceptualization of design as a strategic tool.
  - General consensus on the existence of design thinking.

---

540
Case study 2: Brabham F1 suspension design, 1981

Drivers
- First introduced new rear-wheel drive for Brabham F1 team for 1981 season

Experts
- Graham Humpy and his team at Brabham

Processes
- Using computer simulation to test the suspension

Impact
- Nelson Piquet won his first F1 driver's world title, poles 10x, 3rd place

Case study 3: Mothercare Vic multibuggy, 1985

Drivers
- The design must be safe for babies, every inch from bottom to top

Experts
- Design team at Mothercare

Processes
- 600% increase in design success (DECA, 2010)

Impact
- The new product reduced the infant mortality rate for 50% (DECA, 2010)

1990s

Events in the 1990s
- First time "design thinking" used to describe the process
- Abductive reasoning seen as the logic behind any design activity
- Design thinking's influence began to expand
**Literature from the 1990s**

"Design thinking is competing defining of emerging design problems, combining technical and cultural strategies, and design thinking as a complex interaction of designer and end user."

Michael Cusumano, 1998

"Understanding the success of design: The success of the Swedish design industry."

Herbert Blomqvist, 1993

**Case study 4: Alessi family follows Fiction range, 1991**

**Drivers**

- Research in human emotions and transitional objects.

**Experts**

- Consumer and cultural experts and architects.

**Processes**

- Prototyping and using a multidisciplinary team.

**Impact**

- Most purchased studio design growth in the 1990s.

**2000s**

**Events in the 2000s**

- Interest in non-design sectors
- Design thinking branded as the process that guarantees innovation by practitioners
- New understandings and views created by practitioners

**Literature from the 2000s**

"Design thinking, from the research of the design, to the theory of the design, from the development of the design, to the practice of the design."

Johann Blum, 2009

"Design thinking originated in an academic context from research into the cognitive processes of designers. In the process of designing, researchers study researchers and practice the process of designing."

Anna Blomquist, 2009
Case study 5: Nintendo Wii, 2005

DRIVERS
- Remote sensor technology
- Microsoft and Sony competing heavily

EXPERTS
Core design team cut 95% of design software development

165%
Nintendo massacre
- Price increases
- Product losses

Case study 6: TSA Security Checkpoint Evolution by IDEO, 2009

DRIVERS
- New ways of checking bags detected
- Airport security process

EXPERTS
- JetBlue passenger
-過程

2010s

Events in the 2010s
- Design thinking debate continues
- Non-design sectors integrate design into their operations
- Academic research and new commercial application seems to slowed down
Literature from the 2010s

... Broner's 2010s "new" design thinking approach harnesses a pre-epiphany or pre-crisis phase, or "...". A decade of silent evolution in the evaluation of "...". The evaluation of "...". The evaluation of "...". The evaluation of "...". The evaluation of "...". The evaluation of "...". 

Karen Langmuir, 2010

Design thinking is not the solution to all problems, but it's an essential tool in creative problem solving.

Benjamin, 2009

Design thinking often involves a variety of methods and tools to help designers think in new ways. It is a fundamental approach in product design, service design, and interdisciplinary problem-solving.

Benjamin, 2008
Appendix 5 – Research instrument presentation, May 2013

This presentation is available on www.lborodtresearch.co.uk

---

Inside this presentation...

- Origins of design thinking
- Overview of design thinking literature from the 60s
- A portfolio of case studies

---

Case studies

Throughout the presentation there will be a portfolio of case studies that showcase claims of design thinking being applied in practice.

---

Case studies - common characteristics

These case studies share at least 4 common characteristics:

- Drivers
- Represent
- Impact
- Processes

---

1860s

1860s

Abduction, deduction and induction are not three different forms of argument. Instead they are phases of the methodology of science.

Charles Sanders Peirce, 1865
**Abduction, deduction and Induction**

**Abductive reasoning:**
Create a hypothesis that may or may not be true and which may require further work to verify.

**Deductive reasoning:**
Starts with an accepted hypothesis or theory and deduces specific instances to test if the deduction is true.

**Inductive reasoning**
Is reasoning from specific cases or cases and then generalizing a conclusion or belief from observation in order to make generalizations.

---

**1960s**

---

**Events in the 1960s**

**Design Methods Movement**

**Defining design as a discipline**

Emergence of design thinking as it is understood today.

---

**Literature from the 1960s**

- "The process of design is the translation of ideas into the form of equipment, a method, and experience that makes the idea
disable..." - 1967

---

**Case study 1: The King's Fund Hospital Bed 1965 - 1975**

**Drivers**

- Market research and effort to understand hospital equipment

**Experts**

- A multi-disciplinary team of lean six sigma improvement skills

**Processes**

- Introduced the evidence-based research process for product design

**Impact**

- Up to 80% of old hospital beds still use the same design (IFRA, 2010)
Case study 2: Brabham F1 suspension design, 1981

Case study 3: Mothercare Via multibuggy, 1985

1990s

Events in the 1990s
First time ‘design thinking’ used to describe the process
Additive recycling seen as the logic behind new design activity
Design thinking's influence began to expand
Literature from the 1990s

Visual thinking combines visual and conceptual deliberations, visual thinking and cognitive strategies, visual thinking and cognitive thinking, and visual thinking and cognitive visual thinking.
Mikel Davis, 1996

Design thinking as the inseparability of design - the necessary interaction between design.
Herbert Vossenberg, 1993

CASE STUDY: Alessi Family follows fiction range, 1991

Drivers
Consumer behavior and transitional objects.

Experts
Consumer behavior experts and architects.

Processes
Prosthetic work and using a multidisciplinary team.

Impact
Aesthetically driven double digit growth in the 1990s.

2000s

Events in the 2000s
Interests from non-design sectors
Design thinking renamed as the process that guarantees innovation by practitioners
New understandings and views created by practitioners

Literature from the 2000s

"Design Thinking" originated in an academic context from research into the cognitive processes in design
Annie Boullon, 2009

"Design Thinking" originated in an academic context from research into the cognitive processes in design. In the commercial world, the term is used to describe a process of innovation, creativity, and problem-solving. - Look to place the author of the quote here.
Annie Boullon, 2009
2010s

**Case study 5: Nintendo Wii, 2005**

- **Drivers:** Addition of new technology, Microsoft and Sony overseeing Nintendo
  - Nintendo share price increases
  - Key design team had 25+ years of experience at Nintendo

**Case study 6: TSA Security Checkpoint Evolution by IDEO, 2009**

- **Drivers:** Issues with metal point detection during airport security checks
- **Experts:** Airport staff, passengers, TSA officials, and IDEO designers
  - Rolled out across the USA (now 70 worldwide adaptation)

**Events in the 2010s**

- Design thinking debate continues
- The non-design sector integrates the process into their operations
- Academic research and new commercial application seems to slowed down
Literature from the 2010s

... Bower's [MRT here] design thinking approach presents a post-philosophy, post-deconstructivist, post-phenomenology, post-technology, post-scientific, post-social, post-political, post-everything approach to how design thinking is actually practiced... 

- Rolf Flesseberg, 2010

"Design thinking is a public relations term for good, old-fashioned creative thinking..."

- Don Norman, 2013

"... I have always maintained that designers should not be confused with auteurs. Design thinking has become the hallmark of the modern designer and design studio..."
Appendix 6 – Interview schedule, May 2013

This was the interview schedule used for the main study that took place between June – December, 2013

### Design Thinking Survey February 2013

**NAME:**

**DATE:**

### PART 1

*Please fill in part 1 of the survey before the start of the presentation.*

1. **Your details and occupation**
   
   *This data is collected to allow the researcher to put the participants into the correct groups during data analysis.*
   
   **a)** Your name:
   
   **b)** Are you an academic?  
   
   Circle the answer
   
   - Yes - employed full time
   - Yes - employed part time with other roles outside education
   - No - employed full time outside education
   - No - in full time education (includes full time postgraduate research students)

   **c)** Please give details of your current roles.

   **d)** Do you work in the creative industries?  
   
   Circle the answer
   
   - Yes
   - No
PART 1 CONTINUED

e) Your expertise area within the creative industries:  
(Circle the answer)

(This list was taken from Department of Culture, Media and Sport’s Creative Industries Mapping Document 2001, available from: http://webarchive.nationalarchives.gov.uk/+/http://www.culture.gov.uk/reference_library/publications|4432.aspx)

<table>
<thead>
<tr>
<th>Advertising</th>
<th>Architecture and Antiques Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crafts</td>
<td>Design</td>
</tr>
<tr>
<td>Film &amp; Video</td>
<td>Interactive Leisure Software</td>
</tr>
<tr>
<td>Performing Arts</td>
<td>Publishing</td>
</tr>
<tr>
<td>Television and Radio</td>
<td>OTHER - if selected please go to F</td>
</tr>
</tbody>
</table>

f) Please give details of your area of expertise.

______________________________

______________________________

How many years have you been working in this field?

______________________________

h) Your email address:

______________________________
2. Your knowledge towards design thinking prior the presentation

<table>
<thead>
<tr>
<th>Part 1 Continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Your knowledge towards design thinking prior the presentation</td>
</tr>
<tr>
<td>a) Before participating in this session, have you heard of design thinking?</td>
</tr>
<tr>
<td>Circle the answer</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>b) What do you believe design thinking is?</td>
</tr>
<tr>
<td>c) Have you used or applied design thinking before? Circle the answer</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>
PART 2

Please write your name above and answer the following questions.

1. Your views on design thinking

   a) Did the presentation change your views on design thinking?  
      Circle the answer
      Yes   No

   b) Did the presentation reinforce your views on design thinking?  
      Circle the answer
      Yes   No

   c) If yes, how did the presentation change/reinforce your view and why?

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Loughborough University
PART 2 CONTINUED

c) Do you believe that there are any differences between academics and commercial applications of design thinking? Circle the answer

| Yes | No |


d) Could you write down those differences?
Design Thinking Survey February 2013

PART 2 CONTINUED

2. How accurately was design thinking represented in this presentation.

a) Did the literature in this presentation provide an accurate overview of design thinking since the 1940s? Circle the answer

Yes  No  I don’t know

b) If not could you identify where the inaccuracy was? Circle the answer

1960s  2000s
1970s  2010s
1980s
1990s

c) Please give examples that you believed should have been included and where they should be in the timeline if possible.

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3. Definition of a traditional design problem and a non-traditional design problem
   
   a) Can you define a traditional design problem? Circle the answer
      
      Yes  No
   
   b) Please write down your definition of a traditional design problem.
c) Can you define a non-traditional design problem? Circle the answer

Yes  No

d) Please write down your definition of a non-traditional design problem.
PART 2 CONTINUED

4. Applications of design thinking

Common characteristics:

1) Drivers - External factors that drive the design from market or technological development
2) Experts - Employment of experts from different fields to form multidisciplinary teams to tackle the problem
3) Impact - The result or advantage achieved by using design thinking
4) Process - The unique processes that were used or created during the project

(a) Do you agree with the 4 common characteristics that were listed in the presentation? Circle the answer

Yes  No

(b) Did any of your previous experiences of using design thinking share the listed characteristics? Circle the answer

Yes  No
Design Thinking Survey February 2013

PART 2 CONTINUED

c) If YES, give two examples of you using design thinking that has shared the four characteristics shown in the presentation.


d) If NO, give two examples of you using design thinking and their common characteristics.


PART 2 CONTINUED

e) In addition to the four listed in the presentation are there other characteristics that you can add?

END OF SURVEY

Thank you for participating in this interview and completing the survey.

You may be contacted in the near future for further interviews or other research studies.

For the latest development of the research please visit:

www.lboroDTresearch.ac.uk
Appendix 7 – Participant experience survey, May, 2013

This was the survey participants filled in before taking part in interviews.

IboboDTrsearch Participants' Experience Survey

You and your expertise

Please fill in this survey before taking part in the interview/focus group/seminar sessions thank you.

This data is collected to allow the researcher to put the participants into the correct groups during data analysis.

1. Your name: *

2. Are you an academic? *
   - Yes, employed full time
   - Yes, employed part time with roles outside education
   - No, employed full time outside education
   - No, in full time education (this includes postgraduate research students)

You and your expertise

3. Please give details of your current role(s):

You and your expertise

4. Do you work in the creative industries? *
   - Yes
   - No
5. Your expertise area within the creative industries:

(This list was taken from Department of Culture, Media and Sport's Creative Industries Mapping Document 2001, available from: http://webarchive.nationalarchives.gov.uk/+http://www.culture.gov.uk/reference_library/publications4632.aspx)

-- Please Select --
Advertising
Architecture
Art and Antiques Markets
Crafts
Design
Designer Fashion
Film & Video
Interactive Leisure Software
Music
Performing Arts
Publishing
Software & Computer Services
Television and Radio

6. Please give details of your area of expertise:


7. How many years have you been working in this area? *

8. Your email address: *


You and design thinking

Your knowledge towards design thinking prior the presentation

9. Before viewing the presentation on this website have you heard of design thinking before? *

  ○ Yes
  ○ No
10. What do you believe design thinking is? *


11. Have you used or applied design thinking before?

☐ Yes
☐ No

**You and design thinking**

12. If possible please give details of your previous experience of using design thinking:


**End of survey**

Thank you for filling in the survey. I look forward to seeing you in our interview/ focus group/ seminar session soon.

For the latest development of the research please visit www.lboroD?research.co.uk

Any questions regarding your interview/ focus group/ seminar sessions please email me at a.k.h.chan@lboro.ac.uk.
Appendix 8 – Ethical Advisory Committees (EAC) Checklist

Ethics Approvals (Human Participants) Sub-Committee

Ethical Clearance Checklist

Has the investigator read the 'Guidance for completion of Ethical Clearance Checklist' before starting this form? Yes

Does the study require NHS approval? Please complete a copy of the checklist providing a brief project description in the additional information section. Please send this to the Secretary of the Ethics Approvals (HP) Sub-Committee before starting your NHS application. No

Project Details

1. Project Title: Perspectives of Academics and Practitioners on Design Thinking

Investigator(s) Details

<table>
<thead>
<tr>
<th>2. Name of Investigator 1: Arthur Chan</th>
<th>10. Name of Investigator 2: Click here to enter text</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. School/Department: Design School</td>
<td>12. School/Department: Click here to enter text</td>
</tr>
<tr>
<td>5. Programme (if applicable): PhD</td>
<td>13. Programme (if applicable): Click here to enter text</td>
</tr>
<tr>
<td>6. Email address: <a href="mailto:a.k.h.chan@lboro.ac.uk">a.k.h.chan@lboro.ac.uk</a></td>
<td>14. Email address: Click here to enter text</td>
</tr>
<tr>
<td>7a. Contact address: LDS 1.23, Design School, Loughborough University, Loughborough, Leicestershire LE11 3TU</td>
<td>15a. Contact address: Click here to enter text</td>
</tr>
<tr>
<td>7b. Telephone number: Click here to enter text</td>
<td>15b. Telephone number: Click here to enter text</td>
</tr>
<tr>
<td>8. Supervisor: No</td>
<td>16. Supervisor: Choose an Item</td>
</tr>
<tr>
<td>9. Responsible Investigator: Choose an item</td>
<td>17. Responsible Investigator: Choose an item</td>
</tr>
<tr>
<td>List all other investigators (name/email address): Dr Mark Evans (PhD supervisor) <a href="mailto:m.e.evans@lboro.ac.uk">m.e.evans@lboro.ac.uk</a>; Professor Eddie Norman (PhD supervisor)</td>
<td></td>
</tr>
</tbody>
</table>

Ethics Clearance Checklist October 2015

566
Participants

18. Does the project involve NHS patients from the National Centre for Sport and Exercise Medicine. NHS approval may be required. Please complete a copy of the checklist providing a brief project description in the additional information section. Please send this to the Secretary of the Ethics Approvals (HP) Sub-Committee.

No

Positions of Authority

19. Are investigators in a position of direct authority with regard to participants (e.g. academic staff using student participants, sports coaches using his/her athletes in training)?

Yes†

Vulnerable groups

20. Will participants be knowingly recruited from one or more of the following vulnerable groups?

<table>
<thead>
<tr>
<th>Vulnerable Group</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children under 18 years of age</td>
<td>No</td>
</tr>
<tr>
<td>Persons incapable of making an informed decision for themselves</td>
<td>No</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>No</td>
</tr>
<tr>
<td>Prisoners/Detained persons</td>
<td>No</td>
</tr>
<tr>
<td>Other vulnerable group</td>
<td>No</td>
</tr>
</tbody>
</table>

If Yes to any of question 20, please answer the following questions:

21. Will participants be chaperoned by more than one investigator at all times? N/A†

22. Will at least one investigator of the same sex as the participant(s) be present throughout the investigation? N/A†

23. Will participants be visited at home? N/A†

Investigator Safety

24. Will the investigator be alone with participants at any time? Yes

If Yes to question 24, please answer the following questions:

24a. Will the investigator inform anyone else of when they will be alone with participants? Yes
24b. Has the investigator read the Guidance Notes on ‘Conducting Interviews Off-Campus and Working Alone’ and will abide by the recommendations within?  Yes

Methodology and Procedures

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involves taking bodily samples (please refer to published guidelines)</td>
<td>No</td>
</tr>
<tr>
<td>Involves using bodily samples previously collected with consent for further research</td>
<td>No</td>
</tr>
<tr>
<td>Involves transporting Human Tissue Act relevant material to or from Loughborough (a transfer agreement is required)</td>
<td>No</td>
</tr>
<tr>
<td>Involves procedures which are likely to cause physical, psychological, social or emotional distress to participants</td>
<td>No</td>
</tr>
<tr>
<td>Is designed to be challenging physically or psychologically in any way (includes any study involving physical exercise)</td>
<td>No</td>
</tr>
<tr>
<td>Exposes participants to risks or distress greater than those encountered in their normal lifestyle</td>
<td>No</td>
</tr>
<tr>
<td>Involves collection of body secretions by invasive methods</td>
<td>No</td>
</tr>
<tr>
<td>Prescribes intake of compounds additional to daily diet or other dietary manipulation/supplementation</td>
<td>No</td>
</tr>
<tr>
<td>Involves pharmaceutical drug/medicines</td>
<td>No</td>
</tr>
<tr>
<td>Involves use of radiation</td>
<td>No</td>
</tr>
<tr>
<td>Involves use of hazardous materials</td>
<td>No</td>
</tr>
<tr>
<td>Assists alters the process of conception in any way</td>
<td>No</td>
</tr>
<tr>
<td>Involves methods of contraception</td>
<td>No</td>
</tr>
<tr>
<td>Involves genetic engineering</td>
<td>No</td>
</tr>
<tr>
<td>Involves testing new equipment</td>
<td>No</td>
</tr>
<tr>
<td>Involves testing of medical equipment or devices</td>
<td>No</td>
</tr>
</tbody>
</table>

Observation/Recording

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>26. Does the study involve observation and/or recording of participants?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

27. If Yes to question 26, will those being observed and/or recorded be informed that the observation and/or recording will take place? Yes

Informed consent

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>28. Will participants give informed consent freely?</td>
<td>Yes</td>
</tr>
<tr>
<td>29. Will participants be fully informed of the objectives of the study</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes/No</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>and all details disclosed (preferably at the start of the study but, where this would interfere with the study, at the end)?</td>
<td>Yes</td>
</tr>
<tr>
<td>30. Will participants be fully informed of the use of the data collected (including, where applicable, any intellectual property arising from the research)?</td>
<td>Yes</td>
</tr>
<tr>
<td>31. For children under the age of 18 or participants who are incapable of making an informed decision for themselves:</td>
<td></td>
</tr>
<tr>
<td>a. Will consent be obtained (either in writing or by some other means)?</td>
<td>N/A</td>
</tr>
<tr>
<td>b. Will consent be obtained from parents or other suitable person?</td>
<td>N/A</td>
</tr>
<tr>
<td>c. Will they be informed that they have the right to withdraw regardless of parental/guardian consent?</td>
<td>N/A</td>
</tr>
<tr>
<td>d. For studies conducted in schools, will approval be gained in advance from the Head-teacher and/or the Director of Education of the appropriate Local Education Authority?</td>
<td>N/A</td>
</tr>
<tr>
<td>e. For detained persons, members of the armed forces, employees, students and other persons judged to be under duress, will care be taken over gaining freely informed consent?</td>
<td>N/A</td>
</tr>
<tr>
<td>Deception</td>
<td></td>
</tr>
<tr>
<td>32. Does the study involve deception of participants (i.e. withholding of information or the misleading of participants) which could potentially harm or exploit participants?</td>
<td>No</td>
</tr>
<tr>
<td>If yes to question 32, please answer the following questions:</td>
<td></td>
</tr>
<tr>
<td>33. Is deception an unavoidable part of the study?</td>
<td>Choose an Item</td>
</tr>
<tr>
<td>34. Will participants be de-briefed and the true object of the research revealed at the earliest stage upon completion of the study?</td>
<td>Choose an Item</td>
</tr>
<tr>
<td>35. Will there be an increased physical or emotional risk to participants or investigators when participants are informed of the withholding of information or deliberate deception?</td>
<td>Choose an Item</td>
</tr>
<tr>
<td>Withdrawal</td>
<td></td>
</tr>
<tr>
<td>36. Will participants be informed of their right to withdraw from the investigation at any time and to require their own data to be destroyed?</td>
<td>Yes</td>
</tr>
<tr>
<td>Storage of Data and Confidentiality</td>
<td></td>
</tr>
<tr>
<td>37. Will all information on participants be treated as confidential and not identifiable unless agreed otherwise in advance, and subject to the requirements of law?</td>
<td>Yes</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>38. Will storage of data comply with the Data Protection Act 1998 and the Guidance Note on &quot;Data Protection and Storage&quot;?</td>
<td>Yes</td>
</tr>
<tr>
<td>39. Will any transcripts and video/audio recording of participants be kept in a secure place and not released for any use by third parties?</td>
<td>Yes</td>
</tr>
<tr>
<td>40. Will video/audio recordings be destroyed within ten years of the completion of the investigation or securely archived if required by funder?</td>
<td>N/A</td>
</tr>
<tr>
<td>41. Will full details regarding the storage and disposal of any human tissue samples be communicated to the participants?</td>
<td>N/A</td>
</tr>
<tr>
<td>42. Will research involve the sharing of data or confidential information beyond the initial consent given?</td>
<td>No</td>
</tr>
<tr>
<td>43. Will the research involve administrative or secure data that requires permission from the appropriate authorities before use?</td>
<td>No</td>
</tr>
</tbody>
</table>

**Incentives**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>44. Will incentives be offered to the investigator to conduct the study?</td>
<td>No</td>
</tr>
<tr>
<td>45. Will incentives be offered to potential participants as an inducement to participate in the study?</td>
<td>No</td>
</tr>
</tbody>
</table>

**Work Outside of the United Kingdom**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>46. Is research being conducted by investigators travelling outside of the United Kingdom?</td>
<td>No</td>
</tr>
</tbody>
</table>

*If Yes to question 46, please answer the following questions:*

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>47. Country or countries researcher will travel to for the conduct of the research:</td>
<td>Click here to enter text</td>
</tr>
<tr>
<td>48. Is this the investigator’s home country?</td>
<td>Choose an item</td>
</tr>
<tr>
<td>49. Has a risk assessment been carried out to ensure the physical, emotional and cultural safety of the investigator whilst working outside of the United Kingdom?</td>
<td>Choose an item</td>
</tr>
<tr>
<td>50. Have you considered the appropriateness of your research in the country you are travelling to and checked the FCO guidance: <a href="https://www.gov.uk/foreign-travel-advice">https://www.gov.uk/foreign-travel-advice</a>?</td>
<td>Choose an item</td>
</tr>
<tr>
<td>51. Is there an increased physical, emotional or cultural risk to investigators outside of the United Kingdom as a result of your research study or has the FCO issued a travel warning?</td>
<td>Choose an item</td>
</tr>
<tr>
<td>52. Have you obtained any necessary ethical permission needed in the country you are travelling to?</td>
<td>Choose an Item</td>
</tr>
</tbody>
</table>
53. Will any of the participants be outside of the United Kingdom? | Yes

54. If Yes to 53, is there an increased physical, emotional or cultural risk to participants who are outside of the United Kingdom as a result of taking part in your research study? | No

Risk Assessment

55. Has a risk assessment been carried out and approved by the School, to ensure the physical, emotional and cultural safety of the investigator and participants involved in the study? | Yes

Information and Declarations

† If you have selected answers marked with this symbol you should complete the additional INSURANCE FORM which is available on the Sub-Committee’s website to ensure appropriate insurance cover.

Checklist Application Only:
If you have completed the checklist to the best of your knowledge, and not selected any answers marked with an *, † or ‡, your investigation is deemed to conform with the ethical checkpoints. Please sign the declaration and lodge the completed checklist with your Head of Department/School or his/her nominee.

† Checklist with Additional Information to the Secretary:
If you have completed the checklist and have only selected answers which require additional information to be submitted with the checklist (indicated by a †), please ensure that all the information is provided in detail below and send this signed checklist to the Secretary of the Sub-Committee.

‡ Checklist with Generic Protocols Included:
If you have completed the checklist and selected one or more of the answers marked with this symbol ‡ a full Research Proposal needs to be submitted to the Ethical Approvals (Human Participants) Sub-Committee unless you, or one of the investigators on this project, are a named investigator on an existing Generic Protocol which covers the procedure. Please download the Research Proposal form from the Sub-Committee’s web page. A signed copy of this checklist should accompany the full proposal to the Sub-Committee.

If you, or one of the Investigators on this project, are using a procedure covered by a generic protocol, please ensure the relevant individuals are on the list of approved investigators for that Generic Protocol. Include the Generic Protocol reference number and a short description of how the proposal will be used at the end of the checklist in the space provided for additional information.

The completed checklist should be lodged with your Head of Department/School or his/her nominee.
* Full Application needed:
If on completion of the checklist you have selected one or more answers which require the submission of a full proposal (indicated by a *), please download the Research Proposal form from the Sub-Committee's web page. A signed copy of this Checklist should accompany the full Research Proposal to the Sub-Committee.

Space for Additional Information and/or Information on Generic Proposals as requested:
Click here to enter text.

For completion by Supervisor

Please tick the appropriate boxes. The study should not begin until all boxes are ticked.

☐ The student has read the University's Code of Practice on investigations involving human participants

☐ The topic merits further research

☐ The student has the skills to carry out the research or is being trained in the required skills by the Supervisor

☐ The participant information sheet or leaflet is appropriate

☐ The procedures for recruitment and obtaining informed consent are appropriate

Comments from supervisor:
Click here to enter text.

Signature of Applicant: Arthur Chan

Signature of supervisor (if applicable): Click here to enter text.

Signature of Dean of School/Head of Department or his/her nominee: Click here to enter text.

Date: 31/5/2013
Appendix 9 – Research participants’ consensus form example

Investigating the contrast in understanding/application of design thinking from academic and commercial perspectives.

Participant Information Sheet

Researcher:
Arthur Chan a.k.h.chan@lboro.ac.uk 01509 223578

Research supervisors:
Prof. Eddie Norman e.w.norman@lboro.ac.uk
Dr. Mark Evans m.a.evans@lboro.ac.uk 01509 222656

What is the purpose of this study?
The aim of this PhD is to identify the possible knowledge gap that exists between academics’ and practitioners’ theories of design thinking. An outcome of my PhD research might be the use of its findings to improve the articulation of academic and practitioner theories. Mapping these on to each other would reveal differences in the conceptions of design thinking, the characteristics embodied by particular groups and changes in emphasis.

Who is doing this research and why?
This research will be carried out by myself, Arthur Chan. I am under the sponsorship of Loughborough University.

Once I take part, can I change my mind?
Yes! After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

How long will it take?
Interview sessions will last between 30 minutes to an hour.
Focus group sessions will last between an hour 20 minutes to 2 hours.
Seminars will last between an hour to an hour 30 minutes.
Is there anything I need to do before the sessions?

You will be asked to fill in the LboroDTResearch Participants’ Experience Survey online. The researcher will get in touch with you and give you the details.

What will I be asked to do?

I will ask you questions about design thinking and your expertise. I am interested in your views of design thinking and what you think it is. Your responses will be recorded for qualitative data analysis.

What personal information will be required from me?

In this study I will require your name and details of your occupation. This is only used for putting the participants into the correct groups when it comes to data analysis.

Are there any risks in participating?

There are no risks in participating in this study.

Will my taking part in this study be kept confidential?

When data is collected and throughout this research, your information will be kept at a safe and secure place at Loughborough University. The researcher may use your information in the PhD thesis to provide the context of the research.

What will happen to the results of the study?

The data will be used for my PhD thesis and also for publication. The data will be used anonymously.

I have some more questions who should I contact?

Please contact me or my supervisors via the information provided on the first page.

What if I am not happy with how the research was conducted?

Loughborough University has a policy relating to Research Misconduct and Whistleblowing which is available online at:

http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing[2].htm.
Investigating the contrast in understanding/ application of design thinking from academic and commercial perspectives.

INFORMED CONSENT FORM
(To be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Advisory Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in this study.

Your name

__________________________________________

Your signature

__________________________________________

Signature of investigator

__________________________________________

Date

__________________________________________
Appendix 10 — Full interview notes, participant A-27

For all other interview notes please refer to the Data CD attached.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>You and your expertise</strong></td>
<td></td>
</tr>
<tr>
<td>1. Your name:</td>
<td>cameron</td>
</tr>
<tr>
<td>2. Are you an academic?:</td>
<td>Yes, employed full time</td>
</tr>
<tr>
<td>2. <strong>You and your expertise</strong></td>
<td></td>
</tr>
<tr>
<td>3. Please give details of your current role(s):</td>
<td>Director of Design Studies and Design PhD Program</td>
</tr>
<tr>
<td>3. <strong>You and your expertise</strong></td>
<td></td>
</tr>
<tr>
<td>4. Do you work in the creative industries?</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Your expertise area within the creative industries:</td>
<td>(This list was taken from Department of Culture, Media and Sport’s Creative Industries Mapping Document 2003, available from: <a href="http://webarchive.nationalarchives.gov.uk/+/http://www.culture.guardian.co.uk/creative_library/publications/4622.aspx">http://webarchive.nationalarchives.gov.uk/+/http://www.culture.guardian.co.uk/creative_library/publications/4622.aspx</a>)</td>
</tr>
<tr>
<td>6. <strong>You and your expertise</strong></td>
<td></td>
</tr>
<tr>
<td>6. Please give details of your area of expertise.</td>
<td>Sustainable Design</td>
</tr>
<tr>
<td>7. How many years have you been working in this area?</td>
<td>18</td>
</tr>
<tr>
<td>8. Your email address:</td>
<td><a href="mailto:cam.ema@com.edu">cam.ema@com.edu</a></td>
</tr>
<tr>
<td>4. <strong>You and design thinking</strong></td>
<td></td>
</tr>
<tr>
<td>9. Before viewing the presentation on this website have you heard of design thinking before?</td>
<td>Yes</td>
</tr>
<tr>
<td>10. What do you believe design thinking is?</td>
<td></td>
</tr>
</tbody>
</table>
11. Have you used or applied design thinking before?
Yes

5. You and design thinking

12. If possible please give details of your previous experience of using design thinking:
I teach it
I have run workshops in the not-for-profit sector on it
I have written about it

Response Location
Country: United States
Region: PA
City: Pittsburgh
Postal Code: 15206
Long & Lat: Lat: 40.468102, Long: -79.9114
PART 2

Please write your name above and answer the following questions.

1. Your views on design thinking

   a) Did the presentation change your views on design thinking?  
      Circle the answer
      Yes  [ ] No  [X]

   b) Did the presentation reinforce your views on design thinking?  
      Circle the answer
      Yes  [ ] No  [X]

   c) If yes, how did the presentation change/reinforce your view and why?

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2. How accurately was design thinking represented in this presentation.

a) Did the literature in this presentation provide an accurate overview of design thinking since the 1960s? Circle the answer

- Yes
- No
- I don't know

b) If not could you identify where the inaccuracy was? Circle the answer

<table>
<thead>
<tr>
<th>1960s</th>
<th>2000s</th>
<th>1970s</th>
<th>2010s</th>
<th>1980s</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM,</td>
<td>KI Conference</td>
<td>Moving away</td>
<td>Shift from graphic communication</td>
<td>They were, but not the focus</td>
<td>User centered into interaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Experience, design</td>
</tr>
</tbody>
</table>

C) Please give examples that you believed should have been included and where they should be in the timeline if possible.

- Specifying the designer's cognition
- DTRS
- 90s Design Studies
c) Do you believe that there are any differences between academics and commercial applications of design thinking? Circle the answer.

- Yes
- No

<table>
<thead>
<tr>
<th>d) Could you write down those differences?</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Ability of history</td>
</tr>
<tr>
<td>- Lack of scholarly regard</td>
</tr>
<tr>
<td>- Higher context of what</td>
</tr>
<tr>
<td>- Creative thinking strategy</td>
</tr>
<tr>
<td>- Social innovation</td>
</tr>
<tr>
<td>- UK sector: more design</td>
</tr>
<tr>
<td>- Service design lacking in U.S.</td>
</tr>
</tbody>
</table>

* Vast and massive.  
* Completely different.  
* Design thinking - research for/ by design  
  (social research)  
  Academic - research of design  
  Capability

* Connie Michalski
* Joyce Yeo

www.lboro4research.co.uk

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**Design Thinking Survey February 2013**

**PART 2 CONTINUED**

3. **Definition of a traditional design problem and a non-traditional design problem**

<table>
<thead>
<tr>
<th>a) Can you define a traditional design problem?</th>
<th>Circle the answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) Please write down your definition of a traditional design problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Making a product more sellable, more usable.</td>
</tr>
<tr>
<td>- Enable lifestyle.</td>
</tr>
<tr>
<td>- Domain of artefact to be built.</td>
</tr>
<tr>
<td>m - Artefact: form.</td>
</tr>
<tr>
<td>- Outcome not a design system.</td>
</tr>
<tr>
<td>- Artefact: Surface: non design this</td>
</tr>
</tbody>
</table>

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c) Can you define a non-traditional design problem? Circle the answer

| Yes | No |

---

d) Please write down your definition of a non-traditional design problem.

- Solution is not artefact based.
- T-shaped
  - Vertical timeline
  - Horizontal component
- Complex
- Why does having the B depth enable the breadth?
PART 2 CONTINUED

4. Applications of design thinking

Common characteristics:

1) Drivers - External factors that drive the design from market or technological development
2) Experts - Employment of experts from different fields to form multidisciplinary teams to tackle the problem
3) Impact - The result or advantage achieved by using design thinking
4) Process - The unique processes that were used or created during the project

<table>
<thead>
<tr>
<th>a)</th>
<th>Do you agreed with the 4 common characteristics that were listed in the presentation?</th>
<th>Cycle the answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Yes)</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b)</th>
<th>Did any of your previous experiences of using design thinking share the listed characteristics?</th>
<th>Cycle the answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

- Strategic design
- Multidisciplinary design
- Problem were complex
- Design management spectrum
- People

- Designers know use design thinking

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c) If YES, give two examples of you using design thinking that has shared the four characteristics shown in the presentation.

- Thinking styles: habits of mind, what a particular way of a designer has, habit, emphasis.
- 

- NYPD


d) If NO, give two examples of you using design thinking and their common characteristics.

EXAMPLE:

- NYC, Design Sustainability, Social Innovation.
  - Service Design.
  - Design method.
  - Social Change.

- Exhibition.

- CRITICL: Design, diagram, picture, visual thinking, creating particular tools, a spectrum, or type of evaluation.
Design Thinking Survey February 2013

PART 2 CONTINUED

In addition to the four listed in the presentation are there other characteristics that you can add?

- A disposition, tolerance, capacity, taste, receive
  - The way designers view the world
  - Abductive

- Link between style, choice in fashion
  - Design
  - Style, other way of work

- People love things, designers see people as monsters

END OF SURVEY

Thank you for participating in this interview and completing the survey.

You may be contacted in the near future for further interviews or other research studies.

For the latest development of the research please visit:

www.iborodtresearch.co.uk
Appendix 11  – Participants A-27 interview transcript

For other interview transcripts please refer to the Data CD attached

A-27 interview

Arthur Chan
00:00:00.00
I got what you think design thinking is here, after the presentation did it change any of your views?

A-27
00:00:34.36
Err... No

Arthur Chan
00:00:36.29
Did the presentation reinforce any of your views?

A-27
00:00:40.92
No...

Arthur Chan
00:00:47.08
So basically you are still sticking by what you told me what design thinking is on the four little categories that you wrote down.

A-27
00:00:55.47
Yes... Yes, I thought the case studies that you presented would fit into the categorisation that I was using but I wasn’t thinking too carefully and be too hasty. Looking at your work and the case studies that you presented I would say it fits with my approach.

Arthur Chan
00:01:26.44
You mentioned the case studies, I got them from academics and practitioners, were there anything specifically missing in them, would you have put something that fitted in the profiles?

A-27
00:01:46.24
Some of them seem to be more strategic design than design thinking. In that they were mostly fitted with what I understand the way design problems of larger scales get framed. I wasn’t seeing in the case studies that anything that I thought would cause a conventional larger design consultancy to think this is a new game, a new strategy, different way of working I suppose is what I would characterise as multidisciplinary strategic design in which the designers were participating in multidisciplinary teams and the problems were complex and sometime the designers have the lead role or
sometimes they are just members of the team. More on the design management and strategic design spectrum than some of the stretch that I think people are using design thinking at the moment to try capture.

Arthur Chan
00:03:17.25
Because I did another interview today and some of the case study we discussed with my interviewee earlier this morning when I saw face to face in Birmingham was that design thinking seem to enable designers to move up that one level. Rather than being told what to do we can shape the strategic stuff. Do you think that is an accurateish view?

A-27
00:03:53.53
That is one way to characterise how designers have used design thinking. It related to and slightly different to the way which managers use design thinking. I think to some extent the difference between David Kelly's and Roger Martin's book they are aligned. They are two side of the same coin the books were launched the same time. I went to an event moderated by Nussbaum in New York, both were on stage. They consider themselves in the same space. If you were being strictly academic about it they have completely different purposes.

Arthur Chan
00:04:46.28
Was the books you talked about was it the 10 Faces of Creativity.

A-27
00:04:56.99
No it is Changed by Design. He launched at roughly the same time as Roger's

Arthur Chan
00:05:08.41
The Design of Business.

A-27
00:05:12.27
It is the different between a design firm positioning itself as a management and strategic consultant on the ideas part. And Roger Martin attempting to break the dominance of quantitative thinking in business management.

Arthur Chan
00:05:31.02
Yep because he said out of all the books came out around 2009, there seems to be an influx of those books from my literature review. I presented it in my presentation, Roger Martin's is the only one linked it back to C S Peirce. The others seem to have forgotten
about it.

A-27
00:06:00.41
My critique was that none of these people are aware of the history that is going on and Roger is because he comes from a little more of a scholarly background and some lip service to that. He has some good faculty around him to play that role for him. I was generally dismissive of Tim Brown, although in conversation at the event where the three were speaking, Brown did name a bunch of Design Methods Movement people as pre-cursor to what he is appraising strategically in the book. He gave decent evidence, a decent British education in design; he made it clear that where those ideas are coming from.

Arthur Chan
00:07:07.13
I have spoken to Dave Kelly in a conference in Postdam. I got his older book the 10 Faces of innovation. I got them all line up.

A-27
00:07:33.83
Dave Kelly and Tom Kelly has a new book coming up, so if you go to creative confidence.com.

Arthur Chan
00:07:41.94
I spoke to him via Skype. Did you hear about the d Confestival, hosted in Postdamn the clone of d School in Stanford. I asked him is design thinking done by designers? He said yes, and I need a deeper answer. I asked him how do IDEO convince people, the book Brown wrote never states it. It was interesting that is why I guess there are sceptics around they seems to just talk about achievements and result without telling you what is going that could be trade select. That is my view of it after speaking to me. The whole d School thing seem to be sparring quickly.

A-27
00:08:58.36
It does to some extent. And again I think we need to put it in wider context in universities to see what is going on with technology and research. The d School has no interest in being academic. The way of it set up was strange.

Arthur Chan
00:09:26.20
Was a bunch of them talking that is the legendary version of them.
Hasso Plattner came up with a bunch of money and Dave Kelley asked Steve Jobs what we should do. He said don’t make a degree program because I only hire engineers. No one would hire someone with a design thinking degree, they got to have technical expertise and create and experience that is going to T them in that T personality way. So push them across the top. The d School is odd entirely it is not a school, it doesn’t do a degree. It has faculty attach to it but that don’t do any research in design thinking area. It is tenanting people in design thinking it is merely an experience. While the universities supposingly top tier IVE League universities, you cannot at all consider it to be an academic project. It is as commercial as Tim Brown writing Change by Design.

Arthur Chan
00:10:46.36
They actually do more MBA stuff than actual designing. That is my view I should put that in my research from the people that I spoke to at Stanford, and I asked do you think design thinking has actually moved forward academically or commercially. They replied it still feels the same and it is kind of in the same place. I got the feeling that it has not moved on. I don’t know if you feel that way or not. They are still doing the stuff that are mentioned in the books four years ago.

A-27
00:11:46.49
As far as I understand it remains a kind of creative thinking strategies, it bringing qualitative research with a bit of agile mentally to business and engineering people and that is it.

Arthur Chan
00:12:13.87
So it is not reaching to the people that normally wouldn’t consider it and then it open up a bit for us it is kind of normal.

A-27
00:12:20.69
Yea… And the other side of it is that again through Stanford connection, Stanford for a while was leader in Social Innovation, so the other side of it is bringing that kind of creative thinking workshop mentally to more attractable social problems. To get people to think about how you can be creative in responds to policy and government services. Another interesting thing is that compare to the UK service design and the idea of public sector service design the very substantial field of service design thinking that spurn up from a bunch of consultants, people like that a whole sector in the UK that is actually developed what I would now consider a real distinctive to service design and government services. None of that is in the US.

Arthur Chan
I always thought the US is big with service.

A-27
00:13:37.85
Not at all, IDEO listed but they don't really get any client to pay them to do it in the US all their service design work is based in UK and Europe. There have been two or three attempts to create service design agencies however they have all been folded or brought by regular agencies. The service design community remains marginal and small. The service design space that is growing in the US and perhaps not growing in the UK that I know is thinking about digital services overlapping provider, platform, thinking of your iPhone as a service system which you have a whole series of cooperating, competing players and a whole series of user intentions. App as a software service is very big in the US at the moment. The whole service community here in the US has moved into that kind of tech design space.

Arthur Chan
00:14:35.60
Tech savvy everything is online and Netflix all that lot

A-27
00:14:40.18
That is what backwash back into the government service sector, all the service designers working in the government in the US basically

Arthur Chan
00:14:51.53
That is interesting. Right. Do you believe there is any difference in academic and commercial application of design thinking?

A-27
00:15:03.51
Yes. Vast and very significant and important difference. The quickest way to say this is that for twenty years the Design Thinking Research Symposium has existed, the DTRS you never hear anyone is using design thinking within a trade mark symbol after it mentioning that organisation knowing any of the lecture that occurred. It is a completely different thing in roughly using frazzling distinction DTRS does research design, cognitive science attempt to understand how designers think. The literature picked up the lineage from Cross, Lawson looking in experimental ways at designers design trying to work out the rationalisations are.

Arthur Chan
00:16:03.91
Like what Lawson did with architect kids and science kids.
A-27
00:16:10.12
Whereas design thinking in a commercial, consultancy way is research for design and sometime research by design so the distinction between academic design thinking has been research of design veers the commercial research for design in the social research light, ethnography light, with a bit of creative thinking light, brainstorming, prototyping and then occasionally research by design might be more Liz Sanders kind of generative design where it is verging on participrity design early fuzzy front end of those process. I would say that is the difference and the space between those two has not been bridge either academically or in the commercial sense. That paper that I written which I am now commission to write as a book to work at the space. More from the commercial side back to academic side not as academic text. There are other people, C Mikakisi was doing something like that. He might be at Loughborough or at Lancaster. Do you know him?

Arthur Chan
00:17:36.93
No I don't I think someone in the department might know him.

A-27
00:17:42.45
He is now in a consultancy he was working with... I can't think of it

Arthur Chan
00:17:50.50
Was it a big UK consultancy?

A-27
00:17:54.84
No, his supervisor was, can't remember his name, I can send you a link to his work. He is writing a book on the general style and ambit and capability of embracing design thinking. It is almost the link between management style and design thinking.

Arthur Chan
00:18:26.50
My PhD I am trying to articulate the relationship between the two. Hopefully by seeing the two and people won't call it buff.

A-27
00:18:48.01
From the academic side the DTRS8, I was at UTS, I worked with Dorst. It was vaguely an attempt to make the DTRS to pay attention to the design thinking literature it occurred after 2009.

Arthur Chan
2010 was 8, recent one was in Northumbria.

A-27
00:19:20.31
All those books were round, the interesting side was that Kees was facing an interesting issue at UTS, the guy who is in charge of the business school there embraced design thinking heavily and he was talking a lot to Stanford and thinking that as dean of UTS Business School he was going to bring design thinking to the business school. Whereas the design school was seeing it saying... Come talk to us and so I think Kees organise DTRS as a bit of a way of kind of showing that they had some academic chops in relation to design thinking and in fact Roy Green was supposed to be there. On the last day of the conference and they brought Roy Green in on the last day, he was supposed to be there but spoke to us for half an hour and just talk rubbish. That failed on Kee's part but at least that is the gossip part and that is why DTRS6 was not attempt to get the DTRS community to engage in design thinking.

Arthur Chan
00:20:43.30
I got all the paper that was presented.

A-27
00:20:46.94
They were all on the UTS site at some point. I think it is still on the site.

Arthur Chan
00:20:55.47
I got majority of them I also got the Design Studies, I got the new books that Paul Rogers put together and it was all teh papers in the recent DTRS. I got a lot of those and I need to look at it again.

A-27
00:21:17.54
The other person that is doing work... I am trying to find the email... So... There was a woman who is putting together a book, Joyce Yee. You know Joyce?

Arthur Chan
00:21:40.09
I might have heard about her. I don't know here properly.

A-27
00:21:46.56
Joyce is putting together a pretty substantial book on design thinking based on a bunch of interview and I did a whole strings of interviews with her and the book is call Design Transitions.
Arthur Chan
00:22:21.27
I definitely Google it to see when it is coming out soon.

A-27
00:22:28.03
It will be published by...

Arthur Chan
00:22:35.63
Is Joyce Yee, Y double e? Oh she is in Northumbria!

A-27
00:23:07.23
It's got a listing on Amazon, it is called Design Transitions. Untold stories of how practice design is transitioning.

Arthur Chan
00:23:32.16
I been getting them to get me loads of books lately. I have been getting away with it at the library. She teaching in Northumbria? I might emailed Paul Rogers as well his new title might be professor of design thinking. You got to do the book by...?

A-27
00:24:35.53
No, July I am finishing a collection on sustainable design and I am going to turning to that book it will be a shortish book about 50,000 words published by Reaction.

Arthur Chan
00:24:43.70
Coming out later this year?

A-27
00:24:46.03
Wont come until summer next year.

Arthur Chan
00:24:51.06
Real while!

A-27
00:24:53.23
So you are just sitting at home just writing.
A-27
00:24:57.26
I haven't even started that one, the essay you got which I think is about 10,000-12,000 words is the sketch for it and I gave another paper at the Harvard School of Design. In fact there is somebody else to watch. Harvard GSD, is mostly landscape architecture and architects. Harvard Business School started paying some attention to design thinking when the Business School started to offer a course in design thinking. GSD said you know WTF? Why aren't you talking to us? In fact there is an interview in Dumas magazine the dean of GSD saying WTF, why aren't they talking to us? It is funny I hate architects when their egos get damaged it was that reaction. Harvard has an interesting system where their students are encourage to if they have an interest in something and that is not in the system and they get funds to form a club and get speakers in. So they had an event at Harvard's Design Thinking Club, form mostly by business and a few guys in GSD, Bruce spoke to. That is something to pay attention to they are having another one next summer. I gave a talk there and that will be the later part of the book.

Arthur Chan
00:27:06.79
I didn't know Harvard has a Design Thinking Club that is quite something!

A-27
00:27:10.37
Yea it is worth having a look.

Arthur Chan
00:27:14.66
I might email them, you never know what they do. In terms of literature did the literature I choose or used provide an accurate overview of design thinking since the 60s?

A-27
00:27:41.68
Yea, sure.

Arthur Chan
00:27:45.11
Were there any bits that you thought was a weakness there that weren't quite right?

A-27
00:27:54.62
No, no it was all there.

Arthur Chan
00:27:58.63
So you didn't feel the 80s and 90s were a bit thin compare to the other decades.
A-27
00:28:05.65
I mean they were but that was not the attention back then. I suppose maybe if I had to say one component that was missing dominating the 80s and 90s was the arrival of digital based design.

Arthur Chan
00:28:26.12
The rise of CAD and that lot.

A-27
00:28:28.03
The movement from CAD through to user centred design to interaction kind of a rival to UX which then blended on the West Coast of US with experience design, branding and communication design that lot. The shift from graphic to communication design. That whole side of the import was missing. It is funny if you were to go to ACM and KAI conferences and you were to type in design thinking you get very little in fact what you are seeing is a whole bunch of software engineers departures to get their hands on qualitative social research methods, more creative generative design moments, better ideation strategies so in funny ways in the early 80s-90s and there was a gap because there was all these people just trying to stomach the wave of technology that was coming and I think it becomes an interesting question for a literature review as I said you won't find the phrase design thinking in any human, computer interaction journals, on the other hand you can say understanding cognition and computers via ... Or the Leansberg and the Scandinavian sense and all these people were precursors of Don Norman, and then Wayneridge and all of that in fact fed into IDEO's role in Apple. Consequently because of IDEO who wrote Design Thinking so you might say there is literature there. Academically as an examiner I can get away with saying you get away with it not being there. There is a whole interesting chapter trying to think about.

Arthur Chan
00:30:53.90
In the 80s and 90s there were papers written by Cross and his pals at Open University in the UK that he did talk about thinking design knowledge and efficacy of using technology I did not pay attention to it as I was trying to get a feel of what the term means and if I don't know what it means I can't articulate the relationship. When I did it I felt that might have been the decade that popped up on some people's mind that was thin. (90s)

A-27
00:31:43.25
I would say that is because people were moving away. The DTRS community publishing and studying Design Studies were doing tons of work on the actually specifying the cognition of designers and that was a really productive phase for them. The 80s and 90s were when em...
Arthur Chan
00:32:08.99
Oh yea when Rosenberg said additive reasoning was the core to any design activities.

A-27
00:32:23.75
Yea but I was thinking of... I can't remember who he was at University of Sydney and he was doing architecture and he was a particular contribution to DTRS, he was pumping out PhDs and papers that were looking at everything people would say in a rush way and he would sudden starting overly positive research on. The entire journal of Design Studies in the 1990s why was actually being done in relation to design thinking.

Arthur Chan
00:32:55.11
Ahhh... Yea because I mean all the papers like it seems like 2009 was the year all the books decided to pop out nothing really happened for about 9 years since the millennium and all the books popped out and everyone started arguing about. Even in DTRS8 when the academics got annoyed with Tim Brown and that lot. I don't know where argument is a fair word of just debate is properly the best way to describe it but I guess that was because of what people like Tim Brown wrote and that why academics feel like the need to go out and say there is something else more. It is quite true from the books like Brown's and even Esslinger's they don't referred back to any of the academic origins. They don't have to but I guess that is why there is a debate. Overall I think it was a good overview and it gave an overview to what design thinking history is. I spent quite a long time sorting out the research instrument, spend five months to do trail internally. I knew I had to have a solid enough foundation, or I will get killed form the PhD List.

A-27
00:35:05.14
They are nasty little lot on there...

Arthur Chan
00:35:11.64
Someone had a rant on iOS 7, I was like seriously! I got 15 compete and 12 incomplete one. There was a lady from Canada who completely misunderstood the PhD. She gave me some interesting response. Most of them are interesting I got a load of people from Indiana University I guess because they got a d School from there. Some I followed and I haven't heard back. What I found some people they answered the question they kept chucking down quotes from literature and then I am like that is not useful I want your view, I got what they put down, I got whole folder worth. It was just strange. It was interesting some people they send you around circle and they think they can read one book and know it all. That what they think it is. There are some interesting people and some good feedbacks. I do get some good ones like the common factors you properly remember in the case studies one of the professor she was in charge of the PhD program in Indiana and she said knowledge was another one and that was nice. Overall
positive feedback, like you said that list you have to be very careful before you post. You got to be solid.

**A-27**
00:37:34.33
I think treat it as a resource list not as an advice list.

**Arthur Chan**
00:37:42.17
The way I see it is that I code the answers and I got people in mind I want to interview and some other academics in the UK and people working in consultancies but people from there I am only following up if I pick up something that I think it might be better if they expand it more, they give some funny answer and some people contradict themselves badly without knowing. Can you define a traditional design problem?

**A-27**
00:38:18.51
It depends when you want to go back to originally a design problem would be define as making a product more sellable by making it more useable and then at some point thinking about ways of enabling life styles through particular products communication or environments. So conventional defined design problem would name the domain of artefact that is to be built or whereas you start to move towards strategic design and design thinking when the problem is more open ended as to the nature of the solution. It is still traditional design someone expecting and there should be an artefact but not sure if it was a product, system or environment or communication. You really start to move into design thinking when you realise the outcome is not a design system. You turn to a designer for advice what kind of thing might come out as solution but it is not necessary going to come out as a design. Then I consider it to be a non-traditional design thinking problem.

**Arthur Chan**
00:39:59.89
So it is when people move to open ended, you don’t what is going to happen and the artefact can be any form, product systems or anything.

**A-27**
00:40:12.31
To some extent also is the possibility the solution is not artefact based. The continuum between saying it multidisciplinary design there is going be some sort of artefact communication environment to something in the middle which is all we know is going to be service system to the far end which might be a non-design thing being a more agile or bigger contribution and something evolved overtime and something unfinished those a the moments. And if you still have designers on the team what I value you for is not the vertical bar of the ‘T’ and the horizontal ‘T’. 

**Arthur Chan**
It seems like the T shape is being constantly mentioned that seems to always. It almost sounds a bit lazy of me to put it in as a common factor. I need more work on it. I feel a bit lazy to just to put it down.

A-27
00:41:30.60
I think there some merit to it something about... the question really is why does the vertical component enable the horizontal component why not just talking about humanities broadly educated people why is the need of any verticality. You might say yes I need T shape you have to explain why you think someone. Why someone could do typography might be interesting when they learn how to lock up on their typography and start to engage in social complex problems. Why does having a depth enable a breath?

Arthur Chan
00:42:28.44
Just writing this down.

Arthur Chan
00:42:45.86
Now we are back to the application of design thinking again. In the presentation I gave you 4 common characteristic of design thinking do you agree?

A-27
00:43:02.01
I looked at it again yesterday, remind me again.

Arthur Chan
00:43:09.07
Drivers, experts, impact and processes. These are the four from the six that I got they share.

A-27
00:43:30.21
So yes...

Arthur Chan
00:43:35.12
Did any of your previous experience using design thinking shared this list?

A-27
00:43:49.20
I have always been more interested in suppose then you could coming from the thinking or learning styles way of approaching the world and or habits of mine, way of learning
and approaching the world. I was looking more for that. I can see the way I can drop that into one of your characteristics. I didn't see it as a contradiction to yours, but I was always interested in and emphasis on what is a particular way of approaching the world a designer has, disposition, distribution, capability, habiters something like that to the extent there is an overlap to that emphasis I have and your characteristics, there is no problem just I am interested in the other side.

Arthur Chan
00:44:52.27
The next question is useless, well not quite. If say using the characteristics can give me two additional one that all design thinking problem should share. If you put it in characteristic.

A-27
00:45:22.52
So the two that I kind of think is distinct from some other is a disposition literacy capacity to see and proceed taste regimes. It is something about the way designers view the world in that they see style as integral to the way things are organise not superficial. And there a way which you can say and it sounds obvious on the other hand I think is the link between style as in your choice in fashion and style as in the way you work. Your style of work and I think designers have a capacity make the link between the two and have the ability to abduct from one another. Someone that wear a collar t shirt is going to go for iOS 7 more than some maybe who wear a tie it is a stupid example. Designers can make those leaps.

Arthur Chan
00:46:52.07
It almost like when I sit down as a restaurant I look at the font of the menu I get the feel of the place. I would know if I would be miserable or not! I do it without knowing and I would do that to shops as well with fonts and colour. That support what you say the style choice is the font we or I immediately think of what image it is give me and what kind of emotional response I am giving out to it.

A-27
00:47:43.93
I think that is crucial kind of component that I would add is that the ability to extract and read. The second one, if goes under the name of Bruno... design see people as monsters they see them as people plus things. Everyone else in the world just thinks of tools as neuter instruments to put up. Designers see something different when you have glass on and iPhone on your hands. Fusing between people and things is something that designers can see and others can't. When you hire a designer on a large scale problem that isn't transitionally define as a design problem what you are doing is saying you want someone who can read the problem in terms of style and technical aspects with networks. Those are the two things I don't think mention in any DTRS or Design Thinking literature. They are clear evidence that all designers are designers of interactions and all designers are style masters.
Arthur Chan
00:49:12.57
Now I would talk about it like that. If we use Tim Brown books as an example he didn't say anything about the bike project's looks. He said it triggers your mind I guess that why they did it at IDEO. They don't know it so it wasn't in the book.

A-27
00:49:41.48
The book begins by him saying the way understanding design thinking is forget about style. Everyone say designers are styles and we are more than that lets get more into it. When he does that he is trashing something significant about design. He is playing into the need of the perception of people who think design style is superficial.

Arthur Chan
00:50:08.00
Interesting point... I guess that the thing though I think we just deal with it emotional flip into styles emotionally analysing it. Say when I see some of my female friends got Macs I think they are idiots because they don't know how to use it. I already characterise them without even blinking an eye. I guess that support your thought of people plus things equals... Never thought of it that way! One final thing can you give me two examples of you using design thinking if you can. You have given plenty in teaching sustainable design and teaching design thinking.

A-27
00:51:11.88
Sure... So a quick example is that in NYC I was involved in a DESS project so it is a network of researchers concern about design for sustainability and social innovation this particular methodology is that designers don't come up with the good ideas they find good ideas hidden in the community they community has people already innovating sustainable lifestyle. The job of the designer is to lend them the service design experts so that it can be improved and make it easier to sustain that activity and make models and tool kits via learning the innovation and export them to others. It took a design method it was a very methodological driven process, very clear steps. It applied to question of social change that is kind of an example of design thinking we weren't kind of designing solution to a problem because it has been solved. The job of the designer was just to scale the activity. Within that is never the less part of the exhibition where researchers and designers make a big mistake of using a friendly mordents style layout for the exhibition which betray the style of the practices that these people are engage in there was a real disconnect between what we thought was the scale version of what we were doing. It lost the quality in transition. That was a kind of example failure to the style approach of design thinking.

A-27
00:53:19.36
A second example would be just mainly because most of the work I done is there.
Curriculum design when you bring diagraming and visual thinking to curriculum design it does something very interesting to a way you begin thinking about curriculum. Normally if you just use to spared sheets and charts and word documents with tables. You end up with a standardise curriculum it is only begin when you use a richer visual thinking that you actually come up with more interesting things. Again second example is that it might be all good and well to do it until they have a tool to do a certain type of evaluation. When you create that tool it streamline some of the grading process people adopt the technology because it is more efficient. That is affecting management. When you are just announcing and getting people adopting them doesn't have the give or take. The social technical you have a creating a particular tool has a change in management strategy is a particular example of design thinking.

Arthur Chan
00:54:51.94
Using visual?

A-27
00:54:57.03
And then tools the tool look like it is solving other problem in fact what it did was creating a social technical consolation that allows a new style approaching curriculum to take place that is a very design thinking version of what I call in change in management.

Arthur Chan
00:55:27.63
I will let you know if there are anything in the future. Thank you.
Appendix 12 – Design Thinking Survey, June 2013

This is a PDF of the Design Thinking Survey used during the main study data gathering period from June – December 2013.

Iboredesign Research Design Thinking Survey
March 13

PART 1

Welcome to the iboredesign Research Design Thinking Survey. Please fill in your details before progressing further, thank you.

This data is collected to allow the researcher to put the participants into the correct groups during data analysis.

1. Your name: *

   

2. Are you an academic? *
   
   ○ Yes, employed full time
   ○ Yes, employed part time with roles outside education
   ○ No, employed full time outside education
   ○ No, in full time education (this includes postgraduate research students)

PART 1 Continued

3. Please give details of your current role(s):

   

PART 1 Continued

4. Do you work in the creative industries? *

   

602
5. Your expertise area within the creative industries:


- Please Select --
- Advertising
- Architecture
- Art and Antiques Markets
- Crafts
- Design
- Designer Fashion
- Film & Video
- Interactive Leisure Software
- Music
- Performing Arts
- Publishing
- Software & Computer Services
- Television and Radio

6. Please give details of your area of expertise.


7. How many years have you been working in this area? *

8. Your email address: *

PART 1 Continued
PART 2 Continued

How accurately was design thinking represented in this presentation.

19. Did the literature in the this presentation provide an accurate overview of design thinking since the 1960s?
   - Yes
   - No
   - I don't know

20. If not could you identify where the inaccuracy was? (You can choose more than one)
   - 1960s
   - 1970s
   - 1980s
   - 1990s
   - 2000s
   - 2010s

21. Please give examples that you believed should have been included and where they should be in the timeline if possible.
Part 2 Continued

Definition of a traditional design problem and a non-traditional design problem.

22. Can you define a traditional design problem?
   - Yes
   - No

23. Please write down your definition of a traditional design problem.

24. Can you define a non-traditional design problem?
   - Yes
   - No

25. Please write down your definition of a non-traditional design problem.

PART 2 Continued

Applications of design thinking

COMMON CHARACTERISTICS:

1) Driver: *External factors that are driven by the market or technology.*
2) Experts: Employ experts from different fields to form multidisciplinary teams to tackle the problem.
3) Impact: The result or advantage achieved by using design thinking
4) Process: The processes that were used or developed during the project

26. Do you agree with the 4 common characteristics that were listed in the presentation?
   - Yes
   - No

27. Did any of your previous experiences of using design thinking share the listed characteristics?
   - Yes
   - No

PART 2 Continued

COMMON CHARACTERISTICS:

1) Drivers: External factors that are driven by the market or technology.
2) Experts: Employ experts from different fields to form multidisciplinary teams to tackle the problem.
3) Impact: The result or advantage achieved by using design thinking
4) Process: The processes that were used or developed during the project

28. If yes, give two examples of you using design thinking that has shared the four characteristics shown in the presentation.

PART 2 Continued

COMMON CHARACTERISTICS:

1) Drivers: External factors that are driven by the market or technology.
2) Experts: Employ experts from different fields to form multidisciplinary teams to tackle the problem.
3) Impact: The result or advantage achieved by using design thinking
4) Process: The processes that were used or developed during the project

29. If no, give two examples of you using design thinking and their common characteristics.


Part 2 Continued

COMMON CHARACTERISTICS:

1) Drivers: External factors that are driven by the market or technology
2) Experts: Employ experts from different fields to form multidisciplinary teams to tackle the problem.
3) Impact: The result or advantage achieved by using design thinking
4) Process: The processes that were used or developed during the project

30. In addition to the four listed in the presentation are there other characteristics that you can add?


End of survey

Thank you for taking part in the Design Thinking Survey. You might be contacted in the near future for further research studies.

For the latest development of the research please visit www.lboroDTresearch.co.uk

or email me at a.k.h.chan@lboro.ac.uk.
Appendix 13 – Participant P-5 full Design Thinking Survey respond, June 2013

For other survey responses please refer to the CD attached.
Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem. It is a collaborative and multidisciplinary way of looking at, sketching, and proposing new systems and strategies in business, culture, political systems, health systems and the other organizing frameworks that affect our lives. It puts the user at the center of the design process and considers the many audiences, actors, and relationships in the design and redesign of systems.

11. Have you used or applied design thinking before?
   Yes

5. PART 1 Continued

12. If possible please give details of your previous experience of using design thinking:
   I have used DT in the classroom to frame a collaboration process with students. I have also used DT in corporate settings with a design studio framing business problems and processes to create new cultural solutions inside the businesses.

6. PART 2

13. Did the presentation reinforce your views on design thinking?
   Yes

14. Did the presentation change your views on design thinking?
   No

7. PART 2 Continued

8. If yes, how did the presentation change your view and why?

8. PART 2 Continued

15. If yes, how did the presentation reinforce your view and why?
   It referenced materials with which I was already familiar.

9. PART 2 Continued

16. Do you believe that there are any differences between academic and commercial applications of design thinking?
   Yes

17. If yes could you write down those differences:
   Academic uses of DT generally do not involve redesigning a business process or creating a business case for the work. In commercial applications, part of the work is creating the business case for why the organization should do the work in the first place—why it will be profitable.

10. PART 2 Continued

18. Did the literature in the this presentation provide an accurate overview of design thinking since the 1960s?
19. If not could you identify where the inaccuracy was? (You can choose more than one)

I think Bruce Mau's work, though not always called Design Thinking per se, should be included. His work in reframing wicked problems has influenced so much of what is happening now.

11. Part 2 Continued

21. Can you define a traditional design problem?
   No

22. Please write down your definition of a traditional design problem.
   I don’t know which ‘tradition’ you intend to reference. Graphic design in the US is traditionally: please make this 3D printed project beautiful and as smart as possible. Here is the content—make it great.

23. Can you define a non-traditional design problem?
   No

24. Please write down your definition of a non-traditional design problem.
   For me, it is not traditional to consider the delivery of social services or other social sector work as a design problem. These are the design problems on which I am MOST interested in working.

12. Part 2 Continued

25. Do you agree with the 4 common characteristics that were listed in the presentation?
   No

26. Did any of your previous experiences of using design thinking share the listed characteristics?
   Yes

13. Part 2 Continued

18. If yes, give two examples of you using design thinking that has shared the four characteristics shown in the presentation.

14. Part 2 Continued

27. If no, give two examples of you using design thinking and their common characteristics.
   The Drivers in my work are social and cultural conditions, not market conditions. For example, the cultural condition of downtown Phoenix last year for bicycles was apathy or disengagement. Through a design thinking process, I brought leaders of several bicycle constituencies together to create new ways of generating bike culture. The driver was not a market or a technology.

15. Part 2 Continued
Response Location

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Appendix 14 – Thematic analysis coding sheets
a. Thematic data coding sheets – similarities

14th August 2013

**What is Design Thinking?**

*Academic consensus*

A design methodology that can be used divergently to solve problems in any context and create solutions by using the suitable expertise and knowledge.

*Practice consensus*

A bundle of human centred design led problem solving processes/approaches that address ‘wicked problems’ in any context creatively doing so by asking the right questions.
<table>
<thead>
<tr>
<th>Key themes in academic</th>
<th>Key themes in practice</th>
</tr>
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<tbody>
<tr>
<td><strong>Similarities</strong></td>
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<tr>
<td>Design/Design processes/Design methodology</td>
<td>Design processes/Design led mindset and approaches</td>
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<td>Complex problems/Wicked problems/Social challenges</td>
<td>Wicked problems</td>
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<tr>
<td>Problem solving</td>
<td>Problem solving</td>
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<td>Problem context/ outside design</td>
<td>Outside design (Business, culture, health, political)</td>
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<tr>
<td><strong>Differences</strong></td>
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<td>Divergent</td>
<td>Questions</td>
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</tbody>
</table>
14th August 2013

Similar key themes in academics’ definitions of design thinking

Key:
- Design/Design Processes/Design methodology
- Complex problems/Wicked problems/Social Challenges
- Problem solving
- Problem context
- Outside Design

Addressing a problem using the "design" way of thinking.

The application of creative processes systematically to addressing complex problems and generating possible alternatives and products.

Ways of taking in, using and creating knowledge specific to designing in all its forms.

I find it very unclear, but would just summarise it as the problem-solving process used by many designers. I suspect it’s very similar (or possibly the same as) creative thinking or lateral thinking. It gave me some quotes I haven’t read before, and a few explanations and pieces of historical information I haven’t heard before that clarified some different points of view that exist (but also reinforced other things I already knew).

Design thinking is the application of design process and methods inside and outside typical contexts.

Design methodology

Design thinking should consider the design approach necessary for system design thinking.

Methodology for trans-disciplinary problem solving.

A trained approach to creative thinking.

A shared clear language. The first step of idea’s creation.

An ill-defined hype term for a general method/strategy in essence what designers have always done.
14th August 2013

Key:
Natural Design Processes/Design methodology Complex problems/Wicked problems/Social Challenges Problem solving Problem context
Outside Design

Some of them seem to be more strategic design than design thinking, in that they were mostly fitted with what I understand the way design problems of larger scales get framed. I wasn’t seeing in the case studies that anything that I thought would cause a conventional larger design consultancy to think this is a new game, a new strategy, different way of working. I suppose is what I would characterise as multidisciplinary strategic design, in which the designers were participating in multidisciplinary teams and the problems were complex and sometimes the designers have the lead role or sometimes they are just members of the team. More on the design management and strategic design spectrum than some of the stretch that I think people are using design thinking at the moment to try capture.

The way designers think, strategic design, Design applied to more wicked social challenges. A default design process used by non-designers.

Arguably, a different way of thinking about human needs, problems, aspirations distinct from science, engineering, humanities. Some say that it is, or should be, a key aspect of activities for beyond the realm of professional design.

Big question - meaning different things to different people. For me, design thinking is a way of thinking and acting towards situations of uncertainty where both the problem and any resulting solution may be ill defined or unclear. Design thinking is thinking ahead towards the what may be or future possible. This thought and action is critically supported by design representation. That is, the representation of design intent as such things as sketches, prototypes, drawings, illustrations is not a product of design thinking but a critical element of what it is to engage in design thinking. The construction of design representations is design thinking.

I believe that the term “design thinking” refers to more than one concept: how designers think (design cognition); design tools/processes/approaches that non-designers might use (especially in business), taking a system wide perspective (‘systems thinking’).

My response today is that design thinking is applying the creative methodologies developed by the design community to address any type of problem. Importantly, these methodologies can be applied by designers and non-designers alike.
14th August 2013

Similar key themes in practitioners’ definitions of design thinking

Key:
Design Processes, Design led mind set and approaches, Wicked problems, Problem solving, Outside Design

The particular ways (in an extended cognition sense, that is both in the head and in the world) in which someone who is performing design models, plans and makes decisions, acts, articulates, remembers, directs attention, learns, communicates and reasons.

According to Nigel Cross (1982), there are four primary components of design thinking: it is constructive in nature, addresses “wicked” problems, is solution-focused, and works within a problem solving orientation (but is not just problem solving).

Creative methods for business

A design led mind set and approach to creative problem solving.

Design thinking is an iterative process that involves reframing the problems at hand, thinking bigger, redesigning systems that affect the original problem. It is a collaborative and multidisciplinary way of looking at, sketching, and proposing new systems and strategies in business, culture, political systems, health systems and the other organizing frameworks that affect our lives. It puts the user at the center of the design process and considers the many audiences, actors, and relationships in the design and redesign of systems.

Using truths from descriptive science and practice to abduct artefacts with high utility to one or more persons.

A good way of solving wicked problems following a human centred process with frequent feedback from users. Also involving users on the design process.
14th August 2013

Key:
Design Process, Design led mind set and approaches, Wicked problems, Problem solving, Outside Design

Solving the right problem – that’s the essence. HCD (Human centred design) and all the rest are supplementary. Aesthetic creativity? -- yeah, that too. And, don’t forget, it is brilliant PR. Is design thinking new? No. Is it practiced outside of design? Yes. Do all designers do it? No.

A combination of creative instinct and rigorous research/iterative methodologies.

A creative process in which the ultimate goal is to resolve a problem.

A design process that originates from the user’s POV and grows through brainstorming, collaboration, and prototyping.

An attitude

It is a non-usual way of solve problems used by designers.

Design Thinking is an evolving bundle of approaches focused on creating a more human centred, life centred world.

The use of design and design process in a commercial setting

Yea. And I think design thinking is much more about… first it is human centred rather than data centred it tends to be the approach of many business people and manager use for problem solving. It uses design led approaches; it’s human centred, and it focuses on not finding the right solution by first finding the right question.
b. Thematic coding data sheets – differences

14th August 2013

**What is Design Thinking?**

**Academic consensus**

A design methodology that can be used divergently to solve problems in any context and create solutions by using the suitable expertise and knowledge.

**Practice consensus**

A bundle of human centred design led problem solving processes/approaches that address ‘wicked problems’ in any context creatively doing so by asking the right questions.
14th August 2013

<table>
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<tr>
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<th>Key themes in practice</th>
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14th August 2013

Differences in academics’ definitions of design thinking

Key:
Creative thinking/ Creativity Users Experts/ Multidisciplinary Divergent

Addressing a problem using the “design” way of thinking.

The application of creative processes systematically to addressing complex problems and generating possible alternatives and products.

Ways of taking in, using and creating knowledge specific to designing in all its forms.

I find it very unclear, but would just summarise it as the problem-solving process used by many designers. I suspect it’s very similar (or possibly the same as) creative thinking or lateral thinking. It gave me some quotes I haven’t read before, and a few explanations and pieces of historical information I haven’t heard before that clarified some different points of view that exist (but also reinforced other things I already knew).

Design thinking is the application of design process and methods inside and outside typical contexts.

Design methodology

Design thinking should consider the design approach necessary for system design thinking.

Methodology for trans-disciplinary problem solving.

A trained approach to creative thinking.

A shared clear language. The first step of idea’s creation.

An ill-defined hype term for a general method / strategy in essence what designers have always done.
14th August 2013

Key:
Creative thinking/ Creativity Users Experts/ Multidisciplinary Overgood

Process of iterative checking/experimentation of components of a designed object/experience, working with relevant experts and users to refine all into a new useful, usable, enjoyable and elegant product/experience.

Iterative problem setting and resolving including searches for connections to processes outside or beyond precedent...the designer.

It depends on which way you approach it - as a designer, I believe design thinking is about trying to understand the processes of design work, from analysis of the problem to conception, design, redesign and realisation of solution. I agree with Lucy Kimbell (2011) that design thinking should move from being designer-centred or organization-centred to a more practice theory based approach that views design as a social process. It should include the view that designers need to work reflexively to understand their own agency and also understand the field in which they work.

From outside design, design thinking is a way to try and understand what designers do, as if somehow it’s a magical formula for creativity. I believe that all people have the capacity for creativity, it’s just that designers have honed their skills. So, I believe a social approach to design thinking is also important for non-designers, particularly if they work in teams where they need to communicate their ideas to designers.

A very fancy word promoted by marketing professionals about the designers’ ability to translate descriptive words into images.

It is unclear if a designer or others are employing design thinking when they are designing or when they are thinking about designing.

Design thinking is just a term to refer to what designers know and how they think - designerly way of knowing and thinking.

The way that you will and are structuring research, practices in design. In 1980, a little community in England N.Cross and Archer decided to introduce methods and methodology in design as a way of thinking and new framework of scientific research. Design thinking deals with epistemological, etymologic foundation of design disciplines.
14th August 2013

Key:
Creative thinking/ Creativity Users Experts/ Multidisciplinary Divergent

Divergent thinking
Identifying a problem to solve rather than attempting to immediately solve a solution. See CSM Design against Crime methodology.

Believing design thinking is not a good question I think. It is as wide as an ocean. Design thinking is relates about understanding, doing, creating, explaining etc.

A creative process in human artefact environment analysis, design, and evaluation of product, service and/or brand design to ensure successful innovation/entrepreneurship.

Empathetic engagement in the wider cultural and physical environment, mindfulness and a positive, playful attitude to making/inventing.

Design
Using methods for designing.

The process of creating, from ideation to circumspection.

A way of thinking that is empathetic, divergent and convergent, reiterative and flexible within constraints.

The integration of all types of process thinking.
14\textsuperscript{th} August 2013

**Key:**

- Creative thinking / Creativity
- Users
- Experts / Multidisciplinary
- Divergent

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14th August 2013

Differences in practitioners’ definitions of design thinking

**Key:**

Creative/ Creativity, Human centred/ User centred, Multidisciplinary, Question:

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Key:
Creative/ Creativity Human centred/ User centred Multidisciplinary Questions

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Appendix 15 – Content analysis coding diagrams

Nvivo files of the content analysis is available in the Data CD
a. Identifying support evidence for the seven common characteristics of design thinking via content analysis
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</table>
b. – Identifying the modes of expression within the taught modules of Loughborough University
Entrepreneurship and Innovation

Principally taught by: School of Business and Economics

Module weight: 10
ECTS Credit: 5
Credit Level: 6
Exam weighting: 100
Pre-requisite modules: None

Excluded Combinations: B6C132, B6C134, B8C005, B8C010

Availability: Module is generally available to any student meeting pre-requisites, but numbers may be restricted.

Responsible Examiner: Dr J Holland
Delivery Period: Semester 1

Aims:
The aims of this module are to present a range of issues on entrepreneurship related to the development of technical and non-technical innovation. The module will present a range of topics on small and medium-sized enterprises (SMEs), which are an important channel for the diffusion of technical and non-technical innovation, and to develop relevant transferable skills.

Intended Learning Outcomes:
On completion of this module, students should have the following knowledge, understanding and skills.

Knowledge and Understanding:
- explain the current theories on entrepreneurship;
- discuss the main factors influencing the diffusion of technical and non-technical innovation.
- describe idea generation techniques, idea evaluation techniques and idea protection using intellectual property;
- discuss the finance issues relating to SMEs and innovation;
- evaluate the position of SMEs within the contemporary business environment.

Method of Feedback:
1. Feedback given to students in response to assessed work: Generic written feedback on the examination will appear on module team page after results are published.

2. Developmental feedback generated through teaching activities:
Indicative answers and marking criteria discussed in class sessions; results of in-class tests and quizzes.
Foreign Practice 1 - E3564001

Principally taught by Design School

Module: 20
ECTS Credit: 10
Credit Level: 4
Exam weighting: 0
Prerequisite: None
Availability: Module is available to students meeting pre-requisites listed in their Programme Regulations.
Responsible Examiner: Mr D Stoner
Delivery Period: Semester 1

Aims:
The aims of this module are for the student to:
- Begin to develop good working practices in design
- To develop and foster imaginative and creative capabilities, both individually and in teams
- To place the teaching and learning from other Year 1 modules in a practical design context
- To develop and practice skills in self-directed work practice

Extended Learning Outcomes:
a) Knowledge and Understanding:
On successful completion of this module, the students should be able to:
- Demonstrate an understanding of:
  - Design methodology - problem investigation, solution generation, evaluation and development, detailing and presentation
  - The relationship between a product's internal components, external geometry and the resultant aesthetic impression
  - The effect of colour, texture and material choice on aesthetic impression and user perception
  - Form analysis and synthesis

b) Subject Specific Skills:
(i) Intellectual/cognitive skills:

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
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<tr>
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<tr>
<td>Guided independent study</td>
<td>145</td>
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<td>Total</td>
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Design Practice is a studio and workshop based module exploiting projects which increase in complexity and timescale. There are weekly studio/workshop sessions of 4.5 hours. Contact time Lectures/Seminars/Workshop 54 hours. Assessing time to be self-directed and sustained with background study and project development and completion.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
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<td>Assignment 2</td>
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<td>Total</td>
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</table>

100% coursework; students presenting projects through drawn, written and oral presentations plus display of work. There are two assessed coursework assignments (40% and 60%) supported through formative feedback and weekly staff contact.

Method of Feedback:
1. Feedback given to students in response to assessed work
   - Individual written feedback on coursework
   - Feedback discussed as part of a tutorial

2. Developmental feedback generated through teaching activities
   - Feedback on drafts / work plans
   - Group critiques on work presented
   - Dialogue between students and staff in tutorials
On successful completion of this module, the students should be able to:

- Investigate user and market opportunities and formulate design proposals to meet the requirements of a particular design brief and produce new products through synthesis of ideas from a wide range of sources.

(b) Practical/subject specific skills:

On successful completion of this module, the students should be able to:

- Employ sketch modelling materials, media, techniques, methods, technologies and tools associated with product design, using skill and imagination whilst observing good working practice.
- Understand orthographic projection / engineering drawings.

(c) Key/transferable skills:

On successful completion of this module, the students should be able to:

- Study independently, set goals, manage workloads and meet deadlines.
- Anticipate and accommodate change, work within contexts of ambiguity, uncertainty and unfamiliarity.
- Articulate ideas and information in visual, oral and written forms.
- Interact effectively with others, working as a member of a small group/team.
- Analyse information, formulate independent judgments and articulate reasoned arguments through reflection, review and evaluation.
- Use creativity and innovation in problem solving.

Content:

Knowledge and practice of design methodology; problem investigation, solution generation, evaluation and development, costing and presentation. Forms and techniques of writing, visual and oral presentation. Modelling methods; sketching, detail drawing, workshop practice. Foundation exercises to develop visual awareness; form, line, materiality, colour and texture. Design projects to develop understanding of and ability in the design of consumer products, environments and systems, ergonomics and sustainability.

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**Design Practice 2: DSA6051**

**Principally taught by:** Design School

**Module weight:** 20

**ECTS credits:** 10

**Exam credit:** 4

**Exam weighting:** 0

**Prerequisites:** DSA601

**Availability:** Module is available to students meeting pre-requisites but only if listed in their Programme Specifications.

**Responsible examiner:** Dr. RL Tringingham

**Delivery Period:** Semester 2

**Aims:**

The aims of this module are for the student to:
- Build on the Design Practice 1 module.
- Continue to develop good working practices in design.
- Develop and foster imaginative and creative capabilities, both individually and in teams.
- Place practice and learning from other modules, in a practical design context.
- Develop a basic awareness of the role of design in enterprise.
- Develop and practice skills in safe workshop practice when using a variety of hand and machine tools.

**Intended learning outcomes:**

(a) Knowledge and understanding:

On successful completion of this module students should be able to:
- Demonstrate knowledge and understanding of:
  - The concept of design and design, and the role of the designer, in product development and enterprise.
  - The design process, implementation, generation, evaluation and development, detailing and presentation.
  - The basic principles of design for sustainability.
  - How to plan for practical work in a design and workshop environment.
- (b) Subject specific skills:
(c) Key/transferable skills:

On successful completion of this module students should be able to:

- use as an individual and in teams:
  - identify and analyse what data is needed in a particular design project to inform design decisions;
  - communicate clearly and effectively using oral, visual and written form;
  - present ideas within a design team and to a broader audience.

Content:

Development of design skills and experience. Knowledge and practice of design methodology, problem identification, solution generation, evaluation and development, detailing and presentation. Presentation methods, display boards, report writing and formal written presentation. Use of design tools and software. Concept of design and client. Role of the designer in product development. Design projects which integrate design practice with knowledge and abilities gained from other modules.

Teaching and Learning:

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<th>Hours</th>
<th>Comments</th>
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<tr>
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<td>34</td>
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</table>
Guided independent study: 146
Total: 226

Design Practice 2 is a studio, laboratory, and workshop-based module based on two extended design and make projects. Each week has 4.5 hours of direct study/workshop contact, including 1 hour lecture, design ‘consultancy’ meetings and team tutorials (the remaining time is self-directed study on the on-going design work).

Assessment:

<table>
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<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
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</table>

100% coursework comprising three assignments. Two weighted at 45% (1 in week 6 and 1 in week 12) and one 10% weighted drawing assessment.

Method of Feedback:

1. Feedback given to students in response to assessed work:
   - Individual written feedback on coursework;
   - Feedback discussed as part of a tutorial;
   - Individual feedback on request

2. Developmental feedback generated through teaching activities:
   - Feedback on drafts / work in progress;
   - Group critique on work presented;
   - Studio, laboratory or field trip interaction with tutors;
   - Dialogue between students and staff in tutorials;
   - Specific feedback from specialist staff is “consulting session.”

(1) Intellectual/cognitive skills
On successful completion of the module, students should be better able to:
- Identify, understand, analyse, and discuss (especially through writing and oral presentation) the significance of design activity in a range of contexts.

(2) Practical/subject-specific skills
N/A

(3) Key/transferable skills
On successful completion of the module, students should be better able to:
- Identify and organise evidence to support a proposition; construct a defensible position/discussion and express it in (written and verbal) language so that it is comprehensible to an intended audience/recipient;
- Use the internet efficiently as a research tool, and, appropriately use, interpret and present materials.

Context:

Teaching and Learning:

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Lecture presentations (12 hours total) will be made relating to both of the two assignments and guided reading will be set. Seminars and tutorials usually 12 hours will be held to help develop understanding and support the preparation of the assignments. The remaining time is allocated to gathering evidence, individual reading and the preparation
Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
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180% coursework comprising: two assignments, one 2,000 word essay weighted at 60%, one 15 minute group seminar weighted at 40%.

Method of Feedback:

1. Feedback given to students in response to assessed work:
   - Individual written feedback on coursework
   - Feedback discussed as part of a tutorial

2. Developmental feedback generated through teaching activities:
   - Unique between students and staff in tutorials
   - Feedback on drafts / work plans

Teaching and Learning:

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<th>Hours</th>
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<td>Practical classes and workshops</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

100 hours on average. Teaching and Learning: A series of computer-based activities normally in 1.5 hour blocks. Remaining time will be student self-directed study concerned with the completion of assignments and projects.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Type</th>
<th>Exam</th>
<th>Semester</th>
<th>Exten length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1 - Computer based exercise</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semester 2 - Computer based exercise</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
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</tbody>
</table>
### Module Information

**Course Title:** Computers and Desingers 1 - 12831AMS

**Principality Taught in:** Design School

**Module Code:** 12831AMS

**ECTS Credit:** 5

**Credit Level:** 4

**Exam Weighting:** 0

**Availability:** Module is available to students meeting prerequisites but any F used in their Programme Regulations.

**Responsible Examiner:** Mr KM Hur

**Delivery Period:** Semester 1 and Semester 2

### Aims:

The aims of this module are to obtain a good understanding of the computer workstation and essential software in the design process, including: data management, 3D modeling, exploitation of 3D data in design, and software such as engineering drawing, 3D rendering, and 2D graphics.

### Intended Learning Outcomes:

1. **Knowledge and Understanding:**
   - Upon successful completion of the module, students should be able to recognize the importance of computer workstation, data management, and essential software in the design process.

2. **Skills and Attributes:**
   - **Technical/Professional Skills:**
     - Upon successful completion of this module, students should be able to understand the importance of computer workstation, data management, and essential software in the design process. The concept of 3D digital modeling and modelling strategies, the relevance of 3D digital modeling and modelling strategies, the relevance of 3D digital modeling and modelling strategies in the design process, and the concept of 3D digital modeling and modelling strategies in the design process should be understood.
   - **Practical/Subject-Specific Skills:**
     - Upon successful completion of this module, students should be able to model products using a 3D modeling system, generate product externalities, and engineering drawings from this data, efficiently.

### Feedback Method:

1. **Feedback given to students in response to assessed work:**
   - Individual written feedback on coursework.

2. **Developmental feedback generated through teaching activities:**
Dialogue between students and staff in lab sessions and tutorials

Apply suitable numerical methods to solve basic electrical & electronic engineering problems. Use scientific principles in the modelling and analysis of electronic systems.

(a) Practical/subject specific skills:
On successful completion of this module, students should be able to:
- Design simple electronic circuits using basic discrete components.
- Produce simple schematics of electronic circuits using standard symbols.
- Use electronics simulation tools to design circuits.
- Construct and test simple prototype electronic circuits.

(b) Key/transferable skills:
On successful completion of this module, students should be able to:
- Study independently, set goals, manage workloads and meet deadlines.
- Articulate ideas and information cohesively in visual, oral and written forms.
- Use scientific evidence based methods in the solution of problems.

Content:
- Basic electricity & d.c. theory - current, voltage, resistance and Ohms Law; series and parallel resistors, potential divider, Kirchhoff's laws, input/output resistance, circuit loading and power.
- The use of basic measuring equipment to analyse simple electronic circuits
- Basic d.c. power supplies
- The capacitor and inductor circuits
- Basic semiconductor diodes and transistors
- Digital electronics:
  - Logic circuit design by inspection, Boolean algebra and Karnaugh mapping.
  - The electrical characteristics of common logic families & programmable logic devices.
- Sequential logic, flexible circuits:
  - Simple counting circuits, asynchronous & synchronous counters and electronic displays.
- Basic, Additive and Presetable circuits.
- Elementary binary mathematics.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Tutorial</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Practical classes and workshops 32
Guided independent study 44
Total: 100

Combination of 1 hr lectures and 2 hr practical sessions. This module will be delivered as two 6-credit blocks over the academic year equivalent to two half semesters.
Total student effort for the module: 100 hours on average in total.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
</tr>
</thead>
<tbody>
<tr>
<td>End of year test</td>
<td>50%</td>
<td>In-Class Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall assignment and log book marks</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: 100%

Assessment: Weekly progress tests (30%), the end of year exam (50%).
The 100 credit requirement for progression to Part II must include the 10 credits from this module.

Method of feedback:

1. Feedback given to students in response to assessed work
   Feedback discussed as part of a tutorial;
   Individual feedback as required.
2. Developmental feedback generated through teaching activities.
(c) Intellectual/cognitive skills:

On successful completion of this module students should be able to:

- apply analytical skills in mathematical science to the solution of problems in the mechanics of solids and machines;
- conduct prescribed laboratory investigations into fundamental phenomena in mechanical science and mechanical product performance;
- use mathematical models to describe phenomena in mechanical science and mechanical product performance and relate these to the design features of mechanical products;
- use a basis of practical experience to evaluate the decisions used in designing mechanical elements for technical performance in products;
- apply technical reporting skills in describing and reflecting upon generalised laboratory investigations;
- prepare and compare theoretical and practically derived performance characteristics for mechanical elements and machines.

(c) Practical subject-specific skills:

On successful completion of this module students should be able to:

- set up practical tests in the mechanics laboratory to derive performance characteristics for mechanical devices, elements and machines;
- derive performance characteristics for devices and machines using layout techniques on the drawing board;
- use technical reporting skills to present the results of practical investigations.

(c) Key/transferable skills:

On successful completion of this module students should be able to:

- apply mathematical skills in practical situations;
- articulate ideas and information in visual, oral and written form;
- interact effectively with others working as a member of a small team;
- articulate reasoned arguments through reflection, review and evaluation.

Content:

Solid mechanics:
- Forces in equilibrium, properties of structural sections;
- Newton’s law of motion, control of stability, shapes & strains;
- mechanical properties of materials, stress & strain, material safety, frameworks & structures, work energy & power, power law & springs.
- Mechanics of machines:
- Simple machines theory, variable velocity ratio machines, mechanical devices in machines.
Mechanics for Design - 12056AMBR

Principally taught by: Design School

Modular weight: 10
ECTS Credit: 5
Credit Level: 4
Exam weighting: 60
Pre-requisites: None

Availability: Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner: Dr GA Bingham

Delivery Period: Semester 1 and Semester 2

Aims:
The aims of the module are for the student:
To complete a programme of practical investigations into selected phenomena from the mechanics of solids and machines.
To develop analytical skills for the solution of problems in mechanical science.
To develop an experiential base for the exercising of judgement and perception in mechanical design.

Intended Learning Outcomes:
(a) Knowledge and Understanding:
On successful completion of this module, students should be able to demonstrate an understanding of selected topics in the mechanics of solids and machines including:
-bitumen's laws of motion, centroids & stability, stress & strain, equilibrium of static force systems, properties of structural sections.
Mechanical properties of materials, factor of safety, frameworks & bracing, work energy & power, Hooke's law & springs.
Selected topics in the mechanics of machines including:
Simple machines theory, variable velocity ratio machines, mechanical devices in machines.

(b) Subject Specific Skills

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

A total of 10 one hour lectures followed by 2 hour practical session, tutorial or seminar delivered in two 6 week blocks one in each semester.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Seesaw</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four equally weighted assignments</td>
<td>30%</td>
<td>coursework</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Group design project</td>
<td>30%</td>
<td>coursework</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2 hour end test</td>
<td>40%</td>
<td>In-Class Test</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

One group design, manufacture and evaluation project, a total of 30% coursework (15-page manuscript).
Four equally weighted calculation-based assignments, a total of 30% coursework assessment.
One 2 hour end test for 40% assessment.

Method of Feedback:

1. Feedback given to students in response to assessed work
Individual written feedback on coursework; feedback discussed as part of a tutor; individual feedback on request; model answers; seminar written feedback on examinations.

32
2. Continuous feedback generated through teaching activities

Key Transferable Skills

- Awareness of the ergonomics approach: ability to measure basic aspects of human performance; interpretation and implementation of a project brief; ability to work constructively in a project group

Contents:

- Displays and controls: information and operation; panel design; controls and workplace design; tool design; anthropometry and other methods appropriate for workstation design and evaluation; seating; musculoskeletal complaints.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Seminar</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Group independent study</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Will be based on a series of 10 x 2 hour lectures and seminars. Students are expected to supplement these with directed reading.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropometry practical</td>
<td>20%</td>
<td>coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timed online anthropometry test</td>
<td>20%</td>
<td>In Class Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control panel design exercise -</td>
<td>60%</td>
<td>coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>group submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Principally	Design School
Taught by
Module
weight
ECTS Credit
4
Credit Level
4
Exam
weighting
0
Prerequisite
modules
None
Availability
Module is available to any student meeting pre-requirements, but numbers will be restricted and priority will be given to students for whom the module is listed in their Programme Regulations.
Responsible
Examiner
Dr SG Hodder
Delivery
Period
Semester 1 and Semester 2

Aims:
The aim of this module is to provide students with a grounding in the theory and application of ergonomics at an early stage in their degree.

Extended Learning Outcomes:
Knowledge and Understanding
On completion of this module, students should be able to describe and apply the fundamental ergonomics principles that underpin the design of effective human–equipment interfaces.
Subject-specific skills
i) Intellectual / cognitive skills
On completion of this module students should be able to locate and interpret data on human characteristics and abilities.
ii) Practical / subject specific skills

Total: 100%
Timed online anthropometry test - 24%
Anthropometry practical - 25% (electronic submission)
Critical essay on anthropometric design exercise - 60% (group submission and individual rationale).

Method of Feedback:
1. Feedback given to students in response to assessed work
   Individual written feedback on coursework
2. Developmental feedback generated through teaching activities
   Discussion between students and staff in tutorials
Year 2 Design Practice – 1250001

Principally taught by Design School

Modular weight 25

ECTS Credit 12.5

Credit Level 5

Exams weighting 0

SAP Restriction This module cannot be reassessed in SAP

Prerequisite modules DSA200, DSA202

Availability Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner Dr. P. A. Evans

Delivery Period Semester 1 and Semester 2

Purpose:
The aims of this module are for the student to manage effectively a programme of industrial design involving concept generation, design development and product presentation; focus on the specification of product form and user interface; provide an introduction to the principles of eco design; extend and enhance skills and knowledge developed in Year 1 Design Practice modules and provide a sound foundation for the Design Practice activity of Year 3. Effective time management and ability in oral presentation will be supported and developed.

Intended Learning Outcomes:

(a) Knowledge and understanding

On successful completion of this module, students should be able to demonstrate knowledge and understanding of:

- The definition and communication of product form to meet the client's functional and user needs of a specific market, the process applied to professional industrial design practice, and the design principles applied to consumer products.

Total: 250

Teaching and Learning: Combination of lectures, seminars, studio workshops and tutorials, totalling four hours per week for a 10 week project, plus an intensive ‘Design Week’ exercise over 7 days during which all other timetabled sessions are suspended.

The 10 week project will be taught in either Semester 1 or Semester 2 as a half-year group at a time. The Design Week runs in Week 15 of Semester 1 for the whole year group.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>One presentation &amp; major submission</td>
<td>60%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two presentations &amp; major submission</td>
<td>40%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

Assessment comprises two interim formative presentations and one major submission at 60% for the 10 week project, and one interim presentation and one major submission at 40% from the Design Week.

Assessment: not available in SAP.

Method of Feedback:

1. Feedback given to students in response to assessed work
   - Individual written feedback on coursework;
   - Individual feedback on request;
   - Holistic answers

2. Developmental feedback generated through teaching activities
   - Group critiques on work presented;
   - Studio interaction with tutor
   - Dialogue between students and staff in tutorials;
Subject specific skills

(i) Intellectual/ Cognitive skills

On successful completion of this module, the student should be able to:

- originate design concepts and refine these through development to a final specification;
- identify cost and performance constraints and correlate these into an industrial design proposal, and use a qualitative test to analyse an environmental impact.

(ii) Practical/Subject specific skills

On successful completion of this module, students should be able to:

- employ modelling techniques appropriate to industrial design practice;
- manage time and resources to meet deadlines and deliver to specification.

(iii) Key/ Transferable skills

On successful completion of this module, students should be able to:

- articulate ideas and information in visual, oral and written form;
- analyse information, formulate independent judgments and articulate reasoned arguments through reflection, review and evaluation.

Content:

Project-based design activity with a significant amount of practical work that requires investigation, innovation, creative product synthesis, design communication, environmental assessment and reflection.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar</td>
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</tr>
<tr>
<td>Lecture</td>
<td>14</td>
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<tr>
<td>Practical classes and workshops</td>
<td>24</td>
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</tr>
<tr>
<td>Guided Independent study</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

Principle taught by Design School

Module weight 15
ECTS Credit 7.5
Credit Level 3
Examination weighting 40
Prerequisite module EYE-6007(E)
Availability Module is available to students meeting prerequisite but only if listed in their Programme Regulations
Responsible Examiner Dr DJ Soutvis
Delivery Period Semester 1 and Semester 2

Aims:

The aim of this module is for the student to develop knowledge and skills in applied digital electronics and to become familiar with electronic CAD systems for applications in the design of products and systems. The module seeks to meet the future needs of students as design engineers within the context of industrial and product design.

Intended Learning Outcomes:

a) Knowledge and Understanding

On successful completion of this module, students should be able to demonstrate knowledge and understanding of microcontroller applications, the design of microcontroller systems, essential peripheral components and logic.

b) Subject Specific Skills:

On successful completion of this module, students should be able to:

- use scientific principles in the modeling and analysis of mechanical and electrical systems.
- define the symbolic representation of various electrical and electronic components and their connection in various configurations; and
- interpret common electronic test results (eg oscillograms, etc)
(iii) Practical/subject specific skills:
On successful completion of this module, students should be able to:
- Design, test and evaluate digital and analogue systems to meet a
required product specification.
- Use system design and development tools to develop embedded
systems, integrating their previous understanding of digital electronics
and analogue electronics with an embedded control system.
- Produce schematics of electronic circuits using standard symbols.
- Synthesise comprehensive technical/ laboratory reports.

(iv) Key/transferable skills:
On successful completion of this module, students should be able to:
- Study independently, set goals, manage workloads and meet
deadlines.
- Articulate ideas and information coherently in visual, oral and
written forms.
- Use scientific evidence-based methods in the solution of problems.
- Source and evaluate and manage information from a variety of
sources.
- Use creativity and innovation in problem solving.

Content:
- Transducers and signal conditioning (ADC/DAC systems).
- The implications of embedded systems technology in product design.
- High and low level programming (C, assembler) in embedded systems
design.
- Interfacing, sensors and display.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>12</td>
<td></td>
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<td>Practical classes and workshops</td>
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<tr>
<td>Guided Independent study</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
<td></td>
</tr>
</tbody>
</table>

Combination of 1 hr lectures and 2 hr practical sessions. This module
will be delivered as two 5-week blocks over the academic year
equivalent to two half semesters.

Total student effort for the module: 150 hours on average in total.

Further Mechanics for Design - 11010008

<table>
<thead>
<tr>
<th>Principal</th>
<th>taught by</th>
<th>Design fiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modularity</td>
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<td>ECTG Credit</td>
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<td>Credit Level</td>
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<td>Exam weighting</td>
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<tr>
<td>Pre-requisite modules</td>
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<td></td>
</tr>
</tbody>
</table>
| Availability | Module is available to students needing pre-...
| responsible examiner | Er. GA Bingham |
| delivery period | Semester 1 and Semester 2 |

Aims:
The aims of this module are for the student:
- To complete a programme of practical investigations into selected
phenomena from the mechanics of solids, fluids, and thermal dynamics.
- To develop analytical skills for the solution of problems in mechanical
science.
- To develop an experimental base for the exercising of judgement and
perception in mechanical design.

Intended Learning Outcomes:
Knowledge and understanding:
- a) On successful completion of this module, students should be able to
demonstrate an understanding of:
- Selected topics in the mechanics of solids including:
- Bending and direct stress, shear force, bending moments of beams,
shear and torsion, buckling of columns, momentum, impulse
and impact.
- Selected topics in pneumatics including: systems, operation and
application.
- Selected topics in the mechanics of machines including:
- Centrifugal and centripetal force, dynamics of rotation.
### Assessment

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming Project</td>
<td>30%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam 1</td>
<td>40%</td>
<td>Exam</td>
<td>2</td>
<td>2 hrs</td>
</tr>
<tr>
<td>Laboratory Coursework</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Laboratory coursework (50%), Programming Project (14%), 2hr end of year exam (46%)

The 100 credit requirement for progression to Part C must include the 15 credits from this module.

### Method of Feedback:

1. **Feedback given to students in response to assessed work**
   - Individual written feedback on coursework;
   - Feedback discussed as part of a tutorial;
   - Individual feedback on request.

2. **Developmental feedback generated through teaching activities**
   - Results of Computer Aided Assessment;
   - Dialogue between students and staff in tutorials

### Subject Specific Skills:

1. **Intellectual/cognitive skills:**
   - On successful completion of this module students should be able to:
   - Apply analytical skills in mechanical science to the solution of problems in the mechanics of solids, machines, fluids and thermodynamics;
   - Conduct prescribed laboratory investigations into the fundamental phenomena of mechanical science and mechanical product performance:
   - Use mathematical models to describe phenomena in mechanical science and mechanical product performance and relate these to the design features of mechanical products;
   - Use a basis of practical experience to explain the decisions used in designing mechanical elements for technical performance products;
   - Apply technical reporting skills in describing and reflecting upon prescribed laboratory investigations;
   - Prepare and compare theoretical and practically-derived performance characteristics for mechanical elements and machines.

2. **Practical subject specific skills:**
   - On successful completion of this module students should be able to:
   - Set up practical tests in the mechanics laboratory to derive performance characteristics for mechanical devices, elements and machines;
   - Devise performance characteristics for devices and machines using layout techniques on the drawing board;
   - Use technical reporting skills to present the results of practical investigations.

3. **Key/transferable skills:**
   - On successful completion of this module students should be able to:
   - Apply mathematical skills in practical situations;
   - Articulate ideas and information in visual, oral and written forms;
   - Interact effectively with others working as a member of a small team;
   - Articulate reasoned arguments through reflection, review and evaluation.

### Content:

Selected topics in the mechanics of solids including:
- Stressed solids (stress, strain, Hooke’s law, elastic modulus, Poisson’s ratio, energy in a solid);
- Stress analysis (stress components, stress systems, and stress transformation);
- Bending and direct stress, bending of columns, shear force and bending moment, shear and torsion moments, impact and impact; and in the mechanics of solids including:
centripetal and centripetal force, dynamics of rotation.
Selected topics in mechanics including: systems, operation and application.
Selected topics in fluid mechanics including: Bernoulli’s equation, flow measurement, hydraulics.
Selected topics in thermodynamics including:
First law of thermodynamics, flow measurement, hydraulics.

Teaching and learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Co-research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
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<td></td>
</tr>
<tr>
<td>Tutorial</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

Total student effort for the module 150 hours on average.

A total of 12 one hour lectures, 12 one hour tutorials sessions and 12 two hour practical sessions. Teaching still takes place in 1 six week blocks, one in each semester.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exams Semester</th>
<th>Exams Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple choice test</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam 1</td>
<td>40%</td>
<td>Exam</td>
<td>2</td>
<td>2 hrs</td>
</tr>
<tr>
<td>Group design, manufacture and evaluation project</td>
<td>20%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One online multiple choice test for 25% assessment – semester one.
One group design, manufacture and evaluation project at 40% (25% coursework; 25% exam).
One two hour examination at the end of semester two at 40%.

Sustainable Design

Practicality
Taught by Design School

Course Title: Sustainable Design
ECTS Credit: 10

Prerequisite
None

Availability: Available only to students who meet prerequisites.

Responsible Person
Dr VA Lofthouse

Delivery Period
Semester 1 and Semester 2

Aims:
The aims of this module are to enable students to gain an understanding of sustainable design principles and to develop knowledge and understanding of sustainable design. This module supports the development of communication skills through the use of seminar presentation and practical assignments.

Intended Learning Outcomes:

1) Knowledge and Understanding:
On successful completion of this module students should be able to:
- the concept of sustainability;
- the application of methods and tools for sustainable design.

2) Subject Specific Skills:
On successful completion of the module, students should be able to:
- explain the meaning of sustainable design and its associated concepts.

3) Intellectual/Cognitive Skills:
On successful completion of the module, students should be able to:
- apply design methods and tools to sustainable design.
- communicate effectively in a sustainable design context.

4) Personal and Professional Skills:
On successful completion of the module, students should be able to:
- work collaboratively in a team to achieve sustainable design outcomes.
- manage their time effectively to meet deadlines.

5) Transferable Skills:
On successful completion of the module, students should be able to:
- think critically and creatively in a sustainable design context.
- adapt to new situations and technologies as they arise.
Method of Feedback:

1. Feedback given to students in response to assessed work
   - Individual written feedback on coursework;
   - Feedback discussed as part of a tutorial;
   - Individual feedback on projects;
   - Model answers;
   - General written feedback on examinations.

2. Developmental feedback generated through teaching activities
   - Results of in-class tests and quizzes;
   - Group critiques on work presented;
   - Studio, laboratory or field trips interaction with tutors;
   - Dialogue between students and staff in tutorials.

3. Practical/subject specific skills:
   - On successful completion of the module, students should be able to:
     - Use creativity to support sustainable thinking;
     - Use sustainable design methods and tools.

   - Key/transferable skills:
     - On successful completion of the module, students should be able to:
       - Study independently and meet deadlines;
       - Interact effectively with others, for example, through collaboration, collective endeavour and negotiation;
       - Articulate ideas and information comprehensively in visual, oral and written forms;
       - Present ideas and work to audiences in a range of situations;
       - Source, navigate, retrieve, evaluate, manipulate and manage information from a variety of sources;
       - Employ communication and information technologies;
       - Demonstrate creativity and innovation in problem solving.

Content:

The meaning of sustainable development. Social, economic, and environmental issues concerning sustainability. The use of sustainable design within an industrial context. The effects of emerging legislation. Sustainable design brief. Applications of sustainable design.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tutorial</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>
Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:
Total student effort for the module: 206 hours on average.
In the first 12 weeks there will be lectures, seminars and tutorials covering foundational issues. In semester 2 a design project will be undertaken and all research, analysis and design ideas will be recorded in a logbook. Lectures and tutorials will cover sustainable design methods and tools.
5) Contact time: 42 hours (lectures, seminars, workshops and tutorials 52 hours)
6) Private study: comprising guided reading and preparation associated with seminars and tutorials; student self-directed general reading in the subject area of module; preparation and production of assessed coursework.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Seminar Presentation</td>
<td>15%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam</td>
<td>35%</td>
<td>Exam</td>
<td>1</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Design Project</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One exam (35%) and one group seminar presentation (15%) in semester 1, Design Project (50%) in semester 2.

Method of Feedback:
1. Feedback given to students in response to assessed work:
   - Individual written feedback on coursework;
   - Results of examination;
   - General feedback on exam

2. Developmental feedback generated through teaching activities:
   - Feedback on group work;
   - Group critiques on work presented;
   - Studio, laboratory or field trip interaction with tutors;
   - Dialogue between students and staff in tutorials.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes and workshops</td>
<td>36</td>
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<tr>
<td>Guided Independent study</td>
<td>1.4</td>
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</tbody>
</table>
Design Communication - E31080914

Principally taught by Design School

Module weight 35

ECTS Credit 7.5

Credit Level 5

Exam weighting 0

Prerequisite modules DSA005, DSA002

Availability Module is available to students meeting pre-requisites. Not only if listed in their Programme Regulations.

Responsible Examiner P.M. Sinclair

Delivery Period Semester 1 and Semester 2

Aims:
The aim of this module is for the student to: extend and enhance the industrial design modelling, communication and presentation techniques introduced in part A modules: Computing for Designers 1 and Design Practice 1 and 2.

Extended Learning Outcomes

(1) Knowledge and understanding:
Upon successful completion of the module students should be able to display knowledge and understanding of: a variety of techniques employed in the generation, development and finalisation of industrial design proposals and the communication of design rafaeles; how these techniques can be used to generate: concept designs, detailed design presentations and 3D models.

(2) Skills and attributes:
(i) Intellectual/cognitive skills:
On successful completion of this module students should be able to:
Identify and explain the differences between different 3D modeling

Total: 150

Expected total student effort for the module: 150 hours

Design communication comprises a short series of 1 hour lectures and weekly 1.5 hour studio and computer-based activities across both semesters.

Remaining time will be student self-directed study concerned with the completion of exercises and assignments.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D CAD</td>
<td>59%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design portfolio</td>
<td>53%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: 100%

100% coursework comprising one Design Portfolio at 50% of module credit and one 3D CAD assignment at 50% of module credit. The Design Portfolio to be completed in Semester 1 and the 3D CAD modelling assignment to be completed in stages across the year with the final assessment in Semester 2.

Method of Feedback:

1. Feedback given to students in response to assessed work
Individual written feedback on coursework; feedback discussed as part of a tutorial

2. Developmental feedback generated through teaching activities
Feedback on drafts / work plans; group critiques on work presented; dialogue between students and staff in tutorials
The design of products for manufacture in plastics by injection moulding;
the design of injection mould tools, including commercial mould tool design;
3D solid models using CAD systems;
how to pre-process CAD solid model data to provide 2D/2.5D-CAD output and image output;
manufacturing and materials technology required to design and make a prototype injection mould tool;
materials and manufacture processes selection principles and methodology and how to use them to identify appropriate materials and processing routes for the design of a component;
the factors that influence the key properties of materials used and hence why different materials behave the way they do;
the role of computer-based materials selection techniques;
a selection of different analytical techniques available to identify materials;
how components may be made from different materials and why one material is chosen over another.

b) Subject specific skills:

1. Intellectual/cognitive skills:

On successful completion of this module, students should be able to:

visualise a product in 3D and develop an appropriate CAD modelling strategy (as a CAD model); describe, justify and substantiate proposed design development; develop a strategy to systematically select materials and processes;
discriminate between different engineering materials and appreciate their relative merits for different applications;
discriminate between different manufacturing methods and appreciate their relative merits for different materials and applications.

2. Practical/subject specific skills:

On successful completion of this module, students should be able to:

design a simple, prototype, injection mould tool;
use the manufacture of a simple mould tool;
produce detailed part drawings and assembly drawings;
use 3D solid modelling CAD systems to represent simple products;
use CAD/CAM and conventional machining to make a simple prototype mould tool;
use CAD and graphics software to develop and produce graphic presentation boards;
use computer-based materials selection systems;
use a range of analytical techniques to identify materials and method of manufacture from a disassembled component.

c) Key/transferable skills:

On successful completion of this module, students should be able to:

articulate ideas and information in visual, oral and written forms;
artefact assessment strategies to enable outcomes to be achieved and demonstrated;
Total student effort for the module: 360 hours on average.

Teaching and Learning: A combination of 13 one-hour lectures (typically two per week), 3 CAD/CAM development sessions (1 hour per week), 3 product manufacturability sessions (1 hour per week), 3 computer-aided materials selection sessions (3 hours each); laboratory classes (2 hours per week), and 3 group tutorials (1 hour each), remaining time to be self-directed study concerned with design development, product mould tool manufacture, materials and assignment submission/presentations.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD Test 1</td>
<td>5%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD Test 2</td>
<td>5%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Aided Design</td>
<td>10%</td>
<td>Coursework</td>
<td></td>
<td></td>
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<tr>
<td>Material Assignment</td>
<td>5%</td>
<td>Coursework</td>
<td></td>
<td></td>
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<tr>
<td>CAD model design</td>
<td>5%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group report - Artifice analysis</td>
<td>15%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design briefs</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product manufacture &amp; presentation</td>
<td>35%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
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</tbody>
</table>

100% coursework comprising: one design brief (individual submission); 35%, one CAD model design (individual submission); 10%, one product manufacture and presentation (group submission); 25%. Two coursework tests worth 25%, a report in artefact analysis 25%, computer-based material selection assignment worth 5%.

This module will be taught in either Semester 1 or Semester 2 to a half-year group at a time.

Reassessment of the group submission (35%) and report in artefact.
Method of Feedback:

1. Feedback given to students in response to assessed work

Individual written feedback on coursework

2. Developmental feedback generated through teaching activities

Outcome and assessment criteria:

(a) Practical/subject specific skills:

On successful completion of this module, the students should be able to:

- Plan and prioritise user interface design for interactive products
- Prototype their designs and usability test with target users

(b) Key/transferable skills:

On successful completion of this module, the students should be able to:

- Create user interface design: screen layout, navigation and usability testing
- Select and employ communication and information technologies

Content:

Interactive product design: user experience design, personas and scenarios based design techniques, user interface design, usability testing, user requirements, user centred design process, principles of service design.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>174</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>206</td>
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</tr>
</tbody>
</table>

Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:

- Total student effort for the module: 206 hours on average.
- A combination of lectures and computer laboratory based demonstration, instruction and "hands-on" time (normally 1.5 hours)
User Experience Design – L1059422

Principally taught by:
Design School

Modular weight: 10
ECTS Credit: 10
Credit Level: 5
Exam weighting: 8

Availability: Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner:
Dr. Isak Mitchell

Delivery Period:
Semester 1 and Semester 2

Aims:
The aim of this module is to broaden the experience and skills of the student designer to include knowledge of, and competence with, user-centred design principles and screen-based product design and communication.

Intended Learning Outcomes:

1) Knowledge and Understanding:
On successful completion of this module, the students should be able to demonstrate knowledge and understanding of:
- user-centred experience design;
- identification of key users;
- interactive product design;
- basic principles of screen-based design;
- prototyping construction;
- user experience testing.

2) Subject-Specific Skills:
On successful completion of this module, the students should be able to:
- make judgements about interactive products and services.
Application of Electronics for Design – ELE3007

Principally Taught by

Modular weight
ECTS Credit
Credit Level
Exam weighting
Prerequisite
modules
Availability
Responsible
Examiner
Delivery Period

Design School
10
5
6
40
MDE3007, DTE100 (C)
Module is available to students meeting pre-
requisites but only if listed in their Programme
Regulations.
Dr T Page
Semester 1

Aims:

The aim of this module is for the student to develop knowledge and
skills in the design of programmable electronics and systems. This
module seeks to meet the future needs of students as designers within
the context of industrial design and products.

Intended Learning Outcomes:

A) Knowledge and Understanding

On successful completion of this module, students should be able to
demonstrate knowledge and understanding of:
- Design issues in programmable and embedded electronic control;
- Electrical machinery;
- Printed circuit board design.

B) Subject Specific Skills:

(i) Intellectual/cognitive skills:

On successful completion of this module, students should be able to:
- Use scientific principles in the modelling and analysis of electronic
  systems.

(ii) Practical/subject specific skills:

On successful completion of this module, students should be able to:

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td>40%</td>
<td>Exam 1</td>
<td></td>
<td>2 hrs</td>
</tr>
<tr>
<td>Coursework</td>
<td>60%</td>
<td>Coursework</td>
<td></td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

Two design projects (60%), 2 hour end of semester exam (40%)
The 120 credit requirement for Part C award must include the 12
credits from this module.

Method of Feedback:

1. Feedback given to student in response to assessed work

Individual written feedback on coursework;
Feedback discussed as part of a tutorial;
Individual feedback on request

2. Developmental feedback generated through teaching
activities

Dialogue between students and staff in tutorials;
Results of Design Projects.
design, test and evaluate a control system to meet a required product specification;
produce schematics of electronic circuits using standard symbols;
use electronics tools to design circuits;
construct and test protoboard electronic circuits;
use IT for modeling electronic systems;
synthesize comprehensive technical/laboratory reports.

c) Key transferable skills:
On successful completion of this module, students should be able to:

- use/apply/independently, set goals, manage workloads and meet deadlines;
- articulate ideas and information comprehensively in visual, oral and written form;
- use scientific evidence-based methods in the solution of problems;
- source and evaluate and manage information from a variety of sources;
- use creativity and innovation in problem solving.

Context:
Design of programmable electronic systems.
DC motor control and stepper motor control.
Methods of PCB design and manufacture.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration</td>
<td>2</td>
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<tr>
<td>Practical classes and workshops</td>
<td>3</td>
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<td>Lecture</td>
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<tr>
<td>Tutorial</td>
<td>18</td>
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<tr>
<td>Course independent study</td>
<td>70</td>
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</tr>
<tr>
<td>Total</td>
<td>108</td>
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</tbody>
</table>

Teaching, learning and assessment strategies enable outcomes to be achieved and demonstrated:

A combination of 1 hour lectures and 2 hour practical sessions. This module will be delivered as 13 weekly sessions in semester 1 only.
Total student effort for the module: 168 hours on average in total.

Application of Mechanics for Design DC52008

Practicality

taught by Design School

Modular weight: 10
ECTS Credit: 5
Credit Level: 6
Exam weighting: 40
Prerequisites modules: DC50006 (M)
Availability: Module is available to students meeting prerequisites but only if listed in their Programme Regulations.

Responsible Examiner: Dr GA Bright

Delivery Period: Semester 1

Aims:
This module aims to develop and extend students' understanding of fundamental principles in mechanical science as a tool for evaluating and generating design criteria in mechanical product performance.

Intended Learning Outcomes:

a) Knowledge and Understanding:
On successful completion of this module, students should be able to:

- demonstrate knowledge and understanding of:
  - selected areas in the mechanics of solids including:
    - stress concentration, failure and reliability;
  - selected areas in mechanical design theory including:
    - statistical strength, failure modes and stress analysis; factor of safety;
  - selected areas in the design of machine elements including:
    - friction, lubrication, and wear, bearing systems, tolerances, joining of parts

b) Subject specific skills:

(1) Intellectual/cognitive skills:
On successful completion of this module, students should be able to:
apply analytical skills in mechanical science to the solution of problems in the mechanics of solids, machines, fluids and thermodynamics
apply investigative skills to devise and conduct laboratory investigations into the performance of devices, systems and products
apply mechanical design competencies to evaluate and generate design concepts related to the performance and safety of products
apply technical reasoning skills to the production of persuasive reports on the performance and safety of products.

(b) Practical/subject specific skills:

On successful completion of this module students should be able to:

use laboratory equipment to produce data and quantify performance parameters for mechanical devices, systems and products
use computer packages to analyse data and performance parameters and to generate graphical representations of laboratory results
use manual and computer draughting techniques to specify mechanical devices, systems and products.

c) Key/transferrable skills:

On successful completion of this module students should be able to:

apply mathematical skills in practical situations
apply skills in information technology in presenting data and reports articulate ideas and information in oral and written forms interact effectively with others, working as a member of a small team articulate reasoned arguments through reflection, review and evaluation.

Content:

Solid mechanics and failure & reliability: Stress concentration, Statistical strengths, factors of safety, failure mode and effects analysis, Mechanics of Machines: friction, lubrication and wear, Bearing systems and selection, Tolerances, joining of parts, shafts & related parts.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

Method of Feedback:

1. Feedback given to students in response to assessed work
   Individual written feedback on coursework;
   Feedback discussed as part of a tutorial;
   Individual feedback on request;
   Model answer;
   Exhaustive written feedback on examinations

2. Developmental feedback generated through teaching activities
   Group critiques on work presented;
   Group discussions on field trip interaction with tutors;
   Dialogue between students and staff in tutorials
Teaching, learning and assessment strategies enable outcomes to be achieved and demonstrated.

Total weight for the module: 100%.

Combinations: 12 one-hour lectures (one per week) and 24 hours of tutorial-based tutorials (two hours per week). The course consists of a weekly lecture followed by a tutorial session. Students are expected to use laboratory and workshop facilities and be familiar with computational and empirical experimental arrangements to investigate fundamental principles and design criteria. Investigations may include design, make and test of devices to illustrate given phenomena in mechanics or be chosen by students to support project work in other modules.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual mechanical analysis</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam 1</td>
<td>40%</td>
<td>Exam</td>
<td>1</td>
<td>2 hr</td>
</tr>
<tr>
<td>Group Project</td>
<td>40%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
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</tr>
</tbody>
</table>

One individual mechanical analysis for a total of 20% coursework assessment.

One group design, manufacture and evaluation project for a total of 40% coursework assessment.

One two-hour examination at the end of Semester One at 40%.

### Intended Learning Outcomes:

#### (i) Knowledge and Understanding

By the end of this module, students should be able to:

- Understand the key features of modern user-centred design research methods, techniques and approaches.
- Understand the methods of manufacture normally associated with Assistive Technology products.
- Comprehend the relationship between users, carers, healthcare professionals, designers and manufacturers and strategies used for inclusive new product development in this field.
(c) Intellectual/cognitive skills

By the end of this module students should be able to:
- have an awareness of design research sources and basic skills to extract data relevant to the designing process;
- understand how to assess the user experience within an iterative designing process; and, reflect upon the efficacy of a user-centred approach.

(ii) Practical/subject specific skills

By the end of this module students should be able to:
- demonstrate an ability to define and characterise the physical and cognitive profile of a target user or user group;
- demonstrate an ability to identify the key stakeholders, within Assistive Technology, across product development; apply the given strategies and communication methods to develop and evaluate a new design concept.

(iii) Key and transferable skills

Students should be able to demonstrate:
- an ability to be self-motivating when tackling problems and to plan their work tasks in an effective manner;
- an ability to work effectively as part of a group; and have good interpersonal and communication skills.

Contexts

It will consider the major substantive matters in RTAT product design including the demographic change, specific classes of needs arising from disability and ageing design and other considerations arising from these conditions, the nature of disability, both general and specific, together with a survey of typical development (such as in the case of the grey consumer). Students will investigate usability relating to product design for elderly and disabled people. Students will learn about methods of eliciting information from their target user and reflect on their efficacy (effectiveness of achieving an optimum design solution and cost effectiveness in use of resources). They will explore the infrastructure for the manufacture, marketing and supply of Rehabilitation and Assistive Technology products. Students will learn to identify the relevant parties and their needs when developing a new Rehabilitation Technology/Assistive Technology product.

Teaching and Learning

<table>
<thead>
<tr>
<th>ACTIVITY TYPE</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Principally taught by: Design School

Module weight: 10

ECTS Credit: 5

Credit Level: 4

Exam weighting: 0

Excluded Combinations: DS6015, DT6110

Responsible Examiner: Dr Sj Summerskill

Delivery Period: Semester 1

Notes: This module is a variant of DS6017/DT6110, a 10-credit module offered in Part B. Students undertaking MS module will work alongside the Part B students in the first semester and complete a similar assignment to complete the module. The intended learning outcomes are the same as DS6017/DT6110 but at a lower level.

Intended Learning Outcomes:

1) Knowledge and Understanding

On successful completion of this module, students should be able to:
- demonstrate knowledge of the design process, the design process, the assessment of product designs in terms of fit, reach and vision.

2) Subject specific skills

(i) Intellectual/Cognitive skills

On successful completion of this module, students should be able to:
- reflect upon the importance of ergonomics within the design process, define a strategy for the application of ergonomics to any CAD design project, be able to specify an appropriate virtual ergonomics assessment of an existing product design.
Fieldwork: 15
Lecture: 24
Guided independent study: 53
Total: 100

Total student effort for the module: 100 hours on average.

Lecture and seminar series on subjects including user-centred design philosophy and approaches, analysis of theory and specific tasks (14 hours); practical project work (76 hours); tutorials (10 hours).

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
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<tbody>
<tr>
<td>Assignment 1</td>
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<td>Coursework</td>
<td></td>
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<tr>
<td>Assignment 2</td>
<td>70%</td>
<td>Coursework</td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Design project assignment one: based on formal lecture input, project design and presentation (40%); assignment two: based on practical project work and presentation (60%).

Method of Feedback:

1. Feedback given to students in response to assessed work (individual written feedback on coursework);
2. Developmental feedback generated through teaching activities
   - Results of in-class tests and quizzes;
   - Feedback on drafts / work plans;
   - Group critiques on work presented;
   - Studio, laboratory or field trip interaction with tutors;
   - Dialogue between students and staff in tutorials;
   - Placement visit dialogue / reports;
   - Results of peer-marked tasks

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(T) Practical/Subject specific skills
On successful completion of this module, students should be able to design products from the perspective of the user, evaluate the ergonomics of existing products and prototypes, create virtual users and utilise them in virtual user trials.

(T) Knowledgeable skills
On successful completion of this module, students should be able to work with a typical human modelling system, critically evaluate design concepts and existing products, work effectively as an individual, present information in visual and written forms.

Content:

Human modeling: the application of anthropometry, capability, posture, fit, reach and vision for design assessment in a CAD environment. Design ergonomic principles, strategies and applications. The design of ergonomically useful products. The integration of CAD and human modelling technologies. Case studies taken from various fields including automotive, rail, aerospace, industrial environments, general workplaces and consumer products.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
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</tr>
<tr>
<td>Tutorial</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>160</td>
</tr>
</tbody>
</table>

Total student effort for the module: 100 hours on average.

Teaching and Learning: a combination of lectures (90hrs), CAD sessions (10hrs), project tutorials (10hrs), the remainder taken up with directed reading and assignments.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam length</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

64
Method of Feedback:

1. Feedback given to students in response to assessed work
   Individual written feedback on coursework;
   Feedback discussed as part of a tutorial;
   Individual feedback on request

2. Developmental feedback generated through teaching activities
   Feedback on drafts, weekly plans;
   Group critiques on work presented;
   Studio, laboratory or field trip interaction with tutors;
   Dialogue between students and staff in tutorials

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>3</td>
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<tr>
<td>Tutorial</td>
<td>5</td>
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<tr>
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<td>152</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>200</td>
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</tbody>
</table>

Total student effort for the module: 200 hours on average.

Seminars and tutorials are held in small groups and encouraged students to discuss their ideas. The completed dissertations, presented as a word-processed draft, is handed in for assessment on the first working day after the Easter vacation.
Dissertation: DESIGN SCIENCE

Principally taught by: Design School
Modular weight: 20
ECTS Credit: 15
Credit Level: 6
Exame weighting: 0
Prerequisite modules: None
Availability: Module is available to students meeting prerequisites but only if listed in their Programme Regulations.
Responsible Examiner: Prof ES Ares
Delivery Period: Semester 1 and Semester 2

 Aim:

To develop an in-deep knowledge about an aspect or topic of design in relation to, for instance, professional/occupational activities or the social context. To extend investigative, project management and report writing capability.

Intended Learning Outcomes:

1. Knowledge and understanding:
   - Demonstrate knowledge and understanding of the principles and practice of planning an extended enquiry and presentation in the form of a dissertation.

2. Subject specific skills:
   - Intellectual/cognitive skills:
     - Identify a relevant topic and plan an extended enquiry meeting the requirements of an academic dissertation;
     - Analyze primary data, select appropriate research instruments and gather data effectively.

3. Assessment:

   Assessment Title | Weight | Assessment Type | Exam Semester | Exam length
   1,000 word Report (Semester 1) | 20% | Coursework |
   7,500 word Report (Semester 2) | 80% | Coursework |
   Total | 100% |

Examinations by written report of 1,000 words in Semester 1 (20%) and 7,500 words in Semester 2 (80%), normally in an extended essay of 7,500 words, though it could take other, appropriate forms. The study is presented as a well-processed, bound, illustrated essay.

Method of Feedback:

1. Feedback given to students in response to assessed work
   - Individual written feedback on interim report at the first meeting with the supervisor in Semester 2.

2. Developmental feedback generated through teaching activities
   - Dialogue between students and staff in tutorials;
   - Feedback on drafts of work plans;
   - Meeting seconds.
On successful completion of this module, the students should be able to:

- make judgments about HCI systems;
- gather and communicate user requirements;
- develop persona definitions;
- plan and rationalise interface systems.

(b) Practical/subject specific skills:

On successful completion of this module, the students should be able to:
- produce scenario and persona information;
- create simple interactive screen-based design.

(c) Key/transferable skills:

On successful completion of this module, the students should be able to:
- Create user interface design - screen layouts, navigation and usability testing;
- select and employ communication and information technologies.

Content:

Interface design for products, interface accessibility and usability. User requirements, user centered design process.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td>Lecture</td>
<td>8</td>
<td></td>
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<tr>
<td>Practical classes and workshops</td>
<td>12</td>
<td></td>
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<tr>
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<td>Total</td>
<td>100</td>
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</tbody>
</table>

Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated.

Total student effort for the module: 100 hours on average.

A combination of lectures and computer laboratory-based demonstrations, interactive, and “hands-on” time (minimum 1.5 hours per week). The remaining time for student contact learning.

Computer Aided Modelling and Manufacture – D380025

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Design School</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Delivery Period</td>
<td>Semester 1</td>
</tr>
</tbody>
</table>

**Aims:**

The aims of this module are for the student to be able to develop an advanced knowledge and understanding of CAD/CAM techniques to product design and manufacture.

**Intended Learning Outcomes:**

(a) Knowledge and understanding:

On successful completion of this module students should be able to:
- demonstrate knowledge and understanding of:
  - CAD modelling strategy;
  - 3D rendering;
  - 3D NC machining;
  - virtual prototyping;
  - rapid prototyping;
  - use of advanced CAD systems throughout the product design lifecycle.

(b) Skills and Attributes:

On successful completion of this module students should be able to:
- identify appropriate and effective CAD modelling strategy for any design.
On successful completion of this module, the students should be able to:
- \[ \text{make judgements about FCI systems.} \]
- \[ \text{gather and communicate user requirements.} \]
- \[ \text{develop persona definition,} \]
- \[ \text{plan and rationalize interface systems.} \]

(a) Practical/subject specific skills:
- \[ \text{On successful completion of this module, the students should be able} \]
  - \[ \text{to produce scenario and persona information.} \]
  - \[ \text{to create simple interaction across input device.} \]
- \[ \text{Key/transferable skills:} \]
- \[ \text{On successful completion of this module, the students should be able} \]
  - \[ \text{to create user interface design - screen layout, navigation and usability} \]
  - \[ \text{testing,} \]
  - \[ \text{and employ communication and information technologies.} \]

Content:
- \[ \text{Interface design for products, Interface accessibility and usability, User} \]
  - \[ \text{requirements, User centred design process.} \]

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>1</td>
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<tr>
<td>Lecture</td>
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<tr>
<td>Practical classes and workshops</td>
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</tr>
<tr>
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<td>Total</td>
<td>100</td>
<td></td>
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</tbody>
</table>

Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:
- Total student effort for the module: 100 hours on average.

A combination of lectures and computer laboratory-based demonstrations, instruction and "hands-on" time (normally 1.5 hours per week). The remaining time for student-centred learning and

Computer Aided Modelling and Manufacturing - LIBS1028

Principally Taught by: Design School
Module weight: 10
ECTS Credit: 5
Credit Level: 5
Exam weighting: 30
Prerequisite modules: DSG604, DTB105
Availability: Module is available to students meeting prerequisites but only if Places in their Programme Regulations.
Responsible Examiner: Mr K. Marshall
Delivery Period: Semester 1

Aims:
The aims of this module are for the student to build up core CAD/CAM skills developed in Parts A and B of the programme through the theoretical and practical application of advanced CAD/CAM techniques to product design and manufacture.

Intended Learning Outcomes:

(a) Knowledge and understanding:
- Upon successful completion of the module students should be able to
demonstrate knowledge and understanding of:
- \[ \text{CAD modeling strategy,} \]
- \[ \text{3D modeling;} \]
- \[ \text{virtual prototyping;} \]
- \[ \text{the use of advanced CAD systems throughout the product design} \]
  - \[ \text{process.} \]

(b) Skills and Attributes:
- \[ \text{Intellectual/transferable skills:} \]
- \[ \text{On successful completion of this module students should be able to:} \]
  - \[ \text{identify an appropriate and efficient CAD modeling strategy for any} \]
    - \[ \text{design.} \]
- Provide a concise and industrially relevant explanation of the role of computer-aided technologies at various stages throughout the design process.
- Identify opportunities to exploit CAD/CAM during product design.
- Practical subject specific skills.
- Develop student’s skills in various aspects of computer-aided technologies to provide examples of 3D systems.
- Analyse the requirements of a design and generate an efficient and effective design strategy.
- Use computer systems to simulate simple product behaviour.
- Generate visually impressive 3D rendered output from CAD models.

Key Transferable Skills:
- At the end of this module students should be able to:
  - Plan out a method of problem solving and apply it to several self-contained individual tasks;
  - Present their work visually to a high level of quality;
  - Synthesise the knowledge gained from several sources to create a coherent and consistent view of a given subject area.

Content:
3D surface modelling, the application of hybrid modelling to design and modelling tasks and the identification and application of appropriate CAD tools. Computer simulation of product attributes as an aid to design and development. The use of CAD as part of modern product life cycle management (PLM) systems. 3D rendering, lighting, materials and the generation of realistic visual output. 3D tool path generation and output. CAD geometry import and export, and the properties of neutral file formats.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
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<tr>
<td>Practical classes and workshops</td>
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<td></td>
</tr>
<tr>
<td>Guided independent study</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
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</tbody>
</table>

Total student effort for the module: 160 hours on average.

A combination of 10 x one hour lectures (one per week), 10 x 1.5 hour computer-based exercises (one per week) and 2 x one hour exam / assignment support sessions. Remaining time to be student self-directed study or computer-based exercises, the

Final Year Design Practice - E3503085

Principally

Taught by

Design School

Module weight

ECTS Credit

35

Credit Level

6

Exam weighting

9

SAP Restrictions

This module cannot be reassessed in SAP

Prerequisites

DS300L, DS301S or DS305S / DT8001, DT8198

or DT8109

Availability

Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner

Dr BJ Bith

Delivery Period

Semester 1 and Semester 2

Aims:

The aims of this module are for the student to:
- Integrate and apply knowledge, skills and values from other modules in two significant design projects, one over an extended period of two semesters and one over a constraint period;
- Provide two significant examples of the student’s design and innovation capability for their portfolio and CV.

Intended Learning Outcomes:

(a) Knowledge and understanding:

On successful completion of this module students should be able to:

- Demonstrate the planning and management of a design and development strategy appropriate to a problem or opportunity;
- Demonstrate the appropriate knowledge and skill to develop and employ creative thinking and problem solving techniques for the investigation, design and development phases of the chosen project;
- Demonstrate the ability to identify and apply appropriate knowledge and specific techniques for the investigation, design and development phases of the chosen project;
- Demonstrate the ability to understand the impact of factors, materials and sustainability issues relevant to the design;
- Demonstrate the implementation of appropriate manufacturing processes appropriate to the design output.
Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Type</th>
<th>Semester</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td>30%</td>
<td>Exam</td>
<td>1</td>
<td>1.5 hr</td>
</tr>
<tr>
<td>Coursework</td>
<td>70%</td>
<td>Coursework</td>
<td>1</td>
<td>1.5 hr</td>
</tr>
</tbody>
</table>

70% coursework comprising one project exercise: CAD model, display board rendering, and short report - 800 words (20%) and one 1.5 hour written examination (35%).

Method of Feedback:

1. Feedback given to students in response to assessed work
   - Individual written feedback on coursework;
   - Model answers
2. Developmental feedback generated through teaching activities
   - Feedback on drafts / work plans;
   - Dialogue between students and staff in tutorials;
   - Study, laboratory or field trip interaction with tutors

(b) Subject specific skills

(c) Intellectual/cognitive skills:

On successful completion of this module students should be able to:

- Identify and analyse a problem or opportunity;
- Apply and integrate knowledge, skills and values from other modules such as human factors, materials selection, manufacturing, sustainability;
- Generate and evaluate ideas;
- Identify and use a variety of resources to support design development;
- Regularly review their progress and manage the project;
- Identify and record in an appropriate form, the significant design and prototyping developments, and any issues that arise from these developments, including the product evaluation, manufacturer and product costs;
- Exercise effective judgement at all phases in the development of the project.

(d) Practical/subject specific skills:

On successful completion of this module students should be able to:

- Undertake a product design specification;
- Produce and manage a project plan;
- Gather and evaluate data;
- Generate innovative design proposals;
- Exploit appropriate design modelling techniques to assist in generating, evaluating and communicating design work at all phases of the project;
- Develop innovative design processes;
- Present their ideas at various stages using appropriate techniques;
- Make appropriate decisions and be able to justify them;
- Present information in an appropriate format for a range of different 'audiences';
- Seek formal feedback and be able to apply it to subsequent stages.

Content:

The module has two elements:

The Major Design Project is an extended project operating across the two semesters;
the Design Week exercise is a short, intense, exercise-based brief, pioneered by companies which simulate working to strict deadlines, a skill frequently demanded of designers.

The module focuses on the selection and application of an appropriate design process and its management and enables the student to explore issues identified in the aims and intended learning outcomes.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes and workshops</td>
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</tr>
<tr>
<td>Lecture</td>
<td>23</td>
</tr>
<tr>
<td>Tutorial</td>
<td>45</td>
</tr>
<tr>
<td>Supervised time in study/ workshop</td>
<td>144</td>
</tr>
<tr>
<td>Guided independent study</td>
<td>481</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>709</td>
</tr>
</tbody>
</table>

Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated.

The Major Design Project is supported by weekly lectures and group tutorials. In addition, individual specialist support is available, in areas such as CAD, electronics, materials, ergonomics and sustainability at appropriate points in these modules. The project will be assessed by 3 submissions based on formal project reports and supported by appropriate sketches, sketches, formal boards, computer simulations, 2 and 3D modelling and verbal presentation.

There are two formative assessment points: project brief (week 4, Semester 1) and project planning and risk assessment (week 4, Semester 2).

There are two formative peer assessment points: project assessment (typically week 6, Semester 1) and product aesthetics (typically week 6, Semester 2).

The Design Week will be supported by a variety of project brief presentations and group tutorials. These will be flexibly arranged to accommodate any commercial partners. Submission will be in the form of presentation boards.

Assessment:

Aims:

The Global Studio is a cross-institutional teaching and learning programme with the aim of providing students with skills for working in cross-cultural and geographically distributed workgroups. The module has been designed to support students by giving them the skills and experience in using key tools that will enable them to work successfully with various organisational members in the distributed product development projects. These skills include the following:

- Understanding the impact of distributed design processes on strategies and design outcomes.
- Develop and gain experience in using distance communication.
- Explore cultural issues and concepts with exchanges and evaluation.
- Develop skills in writing and evaluation of design briefs.
- Develop teamwork skills.
- Provide critical feedback.
- Develop the means to implement and communicate the design strategy to a client.

The above skills are becoming increasingly important in new product development as a result of changing global manufacturing environment. Students will be working with external partners located in different geographic locations.

Intended Learning Outcomes:

a) Knowledge and understanding:

On successful completion of this module, the students should be able to demonstrate knowledge and understanding of:

- Inter-cultural communication
Method of Feedback:

1. Feedback given to students in response to assessed work
The assessed coursework will receive immediate individual verbal feedback, followed by
summary written notes and peer feedback notes.
Feedback will also be discussed as part of follow-up tutorials.

2. Developmental feedback generated through teaching activities
Feedback on drafts / work plans;
Feedback on key deliverables and deadlines;
Group critiques on work presented;
Study laboratory or workshop interaction with tutors and technical staff;
Dialogue between students and staff in tutorials.

- use of IT in distributed work settings
- workload and project management
- knowledge transfer and critical reflection

b) Subject specific skills:
1) Intellectual/cognitive skills:
On successful completion of this module, the students should be able to:
develop abilities to:
- dealing with ambiguous and complex issues;
- undertake intercultural communication;
- work within international teams;
- collaborating in cross-cultural contexts
2) Practical/subject specific skills:
effective use of ICT including Web 2.0 technologies to undertake
enquiry-based projects;
and providing feedback to diverse product development team members
3) Key/transferable skills:
On successful completion of this module, the students should be able to
communicate across distance using Web 2.0 technologies.

Content:
The Global Studio will incorporate project-based learning. The delivery and
execution of the projects are underpinned by a design process model with
each stage corresponding to a particular stage in the design process such as:
Research, Design Brief, Design Brief Evaluation, Concept Design,
Concept Evaluation, Design Refinement, Detail Design, Prototyping,
Testing and Design Evaluation. Outcomes from each of the design stages are
informing the subsequent design stage of the projects. For example
this design brief will be informed by the undertaking research.
Module material will be available on line. Information on how to access the
on-line course resource will be provided during the first lecture.
Subsequent lectures and workshops will address these topics:
- using distance communication
- information/knowledge transfer
- designer-client communication (e.g. writing design briefs, communicating
a design strategy to a client and giving feedback)
- awareness of cultural issues and concepts

There are five key milestones throughout the course for the client and
developer groups:
1. Stage Outcomes - Designer - Client
2. Design Brief - Client - Research
3. Development Evaluation - Developer - Client
4. Prototyping and Testing - Build and Test
5. Presentation - Feedback (reflection)

Teaching and Learning:
Foundation Technology (BA route) - 13054004

Principally taught by
Design School

Modular weight
30

ECTS Credit
10

Credit Level
4

Exam weighting
0

Prerequisite modules
Note

Availability
Module is available to students meeting pre-requirements but only if listed in their Programme Regulations.

Responsible Examiner
Mr NP Zanker

Delivery Period
Semester 1 and Semester 2

Aims:

The aims of this module are for the student to develop:
- a basic understanding of technology (electrical, electronic and mechanical systems and materials) as they relate to product design
- a basic capability in employing the shown in the design of products
- and to know where to find appropriate data.

Intended Learning Outcomes:

Intended Learning Outcomes:
1. Knowledge and Understanding
   - Basic understanding of technology (electrical, electronic and mechanical systems and materials) as they relate to product design
   - Basic capability in employing the shown in the design of products
   - Know where to find appropriate data.

2. Skills
   - Application of electronics in design practice: working prototype
   - Breadboard and technical report - week 8 (Semester 2), 10%

Teaching and Learning:

<table>
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<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Practical classes and workshops</td>
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<tr>
<td>Guided Independent study</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Total: 230</td>
<td></td>
</tr>
</tbody>
</table>

Each week will be based on a one hour directed briefing and a two hour laboratory/tutorial session (72 hours). The remaining 120 hours will be spent developing laboratory work and on specific assignments, some of which will be learnt based. A module LEARN site will be used to provide a central resource and structure.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
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<td>Coursework</td>
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<tr>
<td>Design Practice</td>
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<td></td>
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<tr>
<td>Mechanics in</td>
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<tr>
<td>Product Analysis</td>
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<td></td>
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<tr>
<td>Logbook (Week 13</td>
<td>20%</td>
<td>Coursework</td>
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<tr>
<td>Semester 1)</td>
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<tr>
<td>Material</td>
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<tr>
<td>Presentation</td>
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<tr>
<td>Test 1 (Week 12</td>
<td>20%</td>
<td>In-Class Test</td>
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<td>Semester 1)</td>
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<tr>
<td>Test 2 (Week 12</td>
<td>20%</td>
<td>In-Class Test</td>
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<td>Semester 2)</td>
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<tr>
<td>Total:</td>
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</tbody>
</table>

2 tests: week 12 (Semester 1) 20% and week 13 (Semester 2) 20%

Materials presentations: Group presentation - rolling programme (Semester 2) 20%

Logbooks: week 13 (Semester 1) 20%

Application of electronics in design practice: working prototype
Method of Feedback:

1. Feedback given to students in response to assessed work
   Individual written feedback on coursework;
   Individual feedback on request

2. Developmental feedback generated through teaching activities
   Results of in-class tests and quizzes;
   Group critiques on work presented

Applications of mechanics to product analysis - group presentation and
written report - week 12 (Semester 2) 1999

provision of visual format, through a presentation and concept
work; justify the characteristics of a physical and or system-
based product.

(3) Practical/subject specific skills
On successful completion of this module, students should be able to:
record images that effectively transcribe verbal or written semantics;
generate a proposition or design concept to a given design brief;
justify aesthetic design decisions - making use of evidence, both visually
and verbally produce detailed presentation boards communicating
design ideas; use drawing and rendering techniques to communicate
value, form and finish effectively.

(4) Key/transferable skills:
On successful completion of this module, students should be able to:
articulate ideas and information in visual and oral forms; analyse data
and information, formulate independent judgements and articulate
reasoned arguments through reflection, review and evaluation.

Contents:

A lecture, directed study and design project programme, which
explores various aspects of industrial design through analysis, process
and methodology and its evaluation in relation to human and product
interaction. Students will be made aware of social and cultural
significance of predominantly form, introduced to usability and
learning; and apply some of the key methods of collecting aesthetic
and lifestyle data from their local community. Students will reflect on
their work as designers and through group discussions and peer review
leading to an individual aesthetic style based on their own values and
decisions. Students will reflect on the given case-study and
evidence-based methods of aesthetic design through iterative cycles of
design activity.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
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</tr>
<tr>
<td>Tutorial</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

A combination of weekly lectures, seminar/tutorial sessions, including
formative feedback supporting a design research and design exercises;
and lists.
Industrial Design Studies 1 – E35009

Principally taught by Design School

Modular weight 10
ECTS Credit 5
Credit Level 4
Exam weighting 0
Pre-requisite module(s) DSD1007
Availability Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner Mr. GE. Turner
Delivery Period Semester 1 and Semester 2

Aims
The aim of this module is to provide students with a broad understanding of product semantics and introduce them to Brand within the context of Industrial Design Practice. Students will have an opportunity to improve their appreciation of form, colour and texture; be exposed to the use of visual research information; to generate design concepts from a range of data and semantic concepts; to build experience in verbal and visual presentation skills; and, be introduced to related theories, with the outcomes communicated using verbal and written and three dimensional presentation techniques.

Intended Learning Outcomes:

a) Knowledge and Understanding:

On successful completion of this module, students should be able to demonstrate knowledge and an appreciation of: human and product interaction; product semantics; methods of researching visual information; and, methods of communicating design concepts through the production of a proposition and or concept design.

b) Subject specific skills:

1. Intellectual/creative skills:

On successful completion of this module, students should be able to:

- Analyse the appearance of existing products and communicate findings.
- Apply theoretical knowledge of human and product interaction, in a

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Volume</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual research exercise</td>
<td>20%</td>
<td>Coursework</td>
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<td></td>
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<tr>
<td>Design exercise</td>
<td>40%</td>
<td>Coursework</td>
<td></td>
<td></td>
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<tr>
<td>Multiple Choice Test</td>
<td>40%</td>
<td>In-Class Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: 100%

One visual research exercise (20%) and one design exercise (40%), both based on seminar and formal lecture inputs. The multiple choice test (40%) is in week 14 based on lecture content and directed reading.

Method of feedback:

1. Feedback given to students is responsive to assessed work
   - Individual written feedback on coursework
2. Developmental feedback generated through teaching activities
   - Dialogue between students and staff in tutorials;
   - Group critiques on work presented;
   - Results of peer-marked tasks;
   - Results of in-class tests and design exercises.
Industrial Design Studies 2 - IDDES0089

Principally taught by: Design School
Modular weight: 20
ECTS Credit: 15
Credit Level: 5
Exams weighting: 0
Prerequisite modules: EESAC09
Availability: Module is available to students meeting prerequisites but only if listed in their Programme Regulations.
Responsible Examiner: Dr D. E. L. 
Delivery Period: Semester 1 and Semester 2

Aims:
The aim of this module is for students to be introduced to and be able to utilise advanced research Design techniques, such as social inquiry, HEAT (historical, economic, environmental, aesthetic, technological), and brand research, appropriate and relevant tool, techniques and strategies to enable industrial design activity at an enhanced level; evidence-based design decision-making, including appropriate gathering and communication of evidence; techniques to embed research findings into appropriate and realistic product design outcomes.

Intended Learning Outcomes:
1) Knowledge and Understanding:
On successful completion of this module, students should be able to demonstrate knowledge and understanding of:
- Technologies for social, economic, aesthetic, and environmental research; the exploitation of social, economic, aesthetic and environmental factors in design decision-making; the exploitation of social, economic, aesthetic and environmental factors in design decision-making; the exploitation of social, economic, aesthetic and environmental factors in design decision-making.
- Subject-specific knowledge:
- Intellectual cognitive skills:
On successful completion of this module, students should be able to:
- Analyse findings from research activity and convert them into insights and propositions; analyse the appearance of existing products; propose and justify new solutions.

Method of Feedback:
1. Individual feedback on coursework;
2. Feedback discussed in seminars;
3. Individual feedback on request.

3. Developmental feedback generated through teaching activities:
- Group critiques on work presented;
- Studio, laboratory and field trips; interaction with tutors;
- Dialogue between students and staff in tutorials;
- Feedback on drafts/work plans.
appropriate forms to comply with specific requirements. Analyse manufacturing techniques and specify product construction.

3. Practical/subject specific skills:

On successful completion of this module, students should be able to:

- Understand, evaluate and solve technical design problems, focusing on the development of new products.
- Design and produce prototype models.
- Analyse and evaluate materials and processes.
- Communicate effectively with others.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>22</td>
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<tr>
<td>Tutorial</td>
<td>46</td>
</tr>
<tr>
<td>Guided independent study</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
</tr>
</tbody>
</table>

Total student effort for this module: 300 hours on average.

Weekly lecture/tutorial sessions (up to 3 hours per week). Remaining time to be self-directed study.

Context:

A lecture, seminar, and design project programme which explores the issues identified in the aims and intended learning outcomes.

Learning and Teaching:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Lecture</td>
<td>22</td>
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<tr>
<td>Tutorial</td>
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<td>Total</td>
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Assessment:

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Assessment</th>
<th>Weight</th>
<th>Exam</th>
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</thead>
</table>

In order to achieve a passing grade, students must achieve a minimum of 40% in the overall module assessment.

In order to pass the module, students must achieve a minimum of 40% in the overall module assessment.

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understand how to involve the user experience within an iterative design process; and, reflect upon the efficacy of a user-centred approach.

2. Practical/subject specific skills
By the end of this module students should be able to:
- demonstrate an ability to define and characterise the physical and cognitive profile of a target user or user group;
- demonstrate an ability to identify the stakeholders within Assistive Technology needs/product development; apply the given strategies and communication methods to develop and evaluate a new design concept.

(c) Key and transferable skills
Students should be able to demonstrate:
- an ability to be self-motivating when tackling problems and to plan their work tasks in an effective manner;
- an ability to work effectively as part of a group; and, have good interpersonal and communication skills.

Content:

It will consider the major substantive matters in RAAT product design including the demographic change, specific classes of needs arising from disability and ageing design and other considerations arising from these conditions, the nature of disability both personal and specific, together with a survey of topical development (such as the rise of the e-pity consumer). Students will investigate usability relating to product design and in particular for elderly and disabled people. Students will learn about methods of obtaining maximum information from their target user and reflect on their efficacy (effectiveness of achieving an optimum universal design solution and user effectiveness in use of resources). They will explore the infrastructure for the manufacture, marketing and supply of Assistive and Adaptive Technology products. Students will learn to identify the relevant parties and their needs when developing a new Rehabilitation Technology/Assistive Technology product.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorials</td>
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<tr>
<td>Lectures</td>
<td>42</td>
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<tr>
<td>Guided independent study</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Intended Learning Outcomes:

(a) Knowledge and Understanding:

After successful completion of this module, students should be able to demonstrate knowledge and understanding of:
Total: 300

Total student effort for the module: 209 hours on average.

Lecture and seminar series on subjects including engineering data analysis, design philosophy and approaches, analysis of specific code (20 hours); practical project work (140 hours); tutorials (20 hours) undertaking assessment (62 hours)

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam</th>
<th>Semester</th>
<th>Exam length</th>
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</thead>
<tbody>
<tr>
<td>Assignment 1 presentation</td>
<td>15%</td>
<td>Coursework</td>
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<tr>
<td>Assignment 2 presentation</td>
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<td>Coursework</td>
<td></td>
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</tr>
<tr>
<td>Assignment 1 report</td>
<td>35%</td>
<td>Coursework</td>
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<td></td>
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</tr>
<tr>
<td>Assignment 2 report</td>
<td>35%</td>
<td>Coursework</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TOTAL</td>
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</tbody>
</table>

Design project assignment one, based on formal lecture input, and an practical project work, resulting in a presentation (15%), assignment two will be based upon project work culminating in a presentation (15%) and a written report (35%), assessment loy will be based upon project work culminating in a presentation (15%) and a written report that is in an internet-ready publish format (35%).

Method of Feedback:

1. Feedback gives to students in response to assessed work
   - Individual written feedback on coursework
   - Individual written feedback on coursework

2. Developmental feedback generated through teaching activities:
   - Results of in class tests and quizzes;
   - Results of in class tests and quizzes;
   - Group discussion on work presented;
   - Group discussion on work presented;
   - Dialogue between students and staff in tutorials;
   - Dialogue between students and staff in tutorials;
   - Results of peer-marked tasks;
   - Results of peer-marked tasks;

(a) Intellectual/cognitive skills:

On successful completion of this module, students should be able to:
- Visualise a product in 3D and develop an appropriate CAD modeling strategy to represent it as a CAD model;
- Describe, justify and substantiate proposed design development;
- Develop a strategy to systematically select materials/manufacturing processes;
- Discriminate between different engineering materials and appreciate their relative merits for different applications;
- Discriminate between different manufacturing methods and appreciate their relative merits for different materials and applications.

(b) Practical/subject specific skills:

On successful completion of this module, students should be able to:
- Design a simple, prototype injection mould tool;
- Plan the manufacture of a simple mould tool;
- Produce detailed part drawings and assembly drawings;
- Use 3D solid modeling CAD systems to represent simple products;
- Use CAD/CAM and conventional machining to make a simple prototype mould tool;
- Use computer-aided materials selection; use a range of analytical techniques to identify materials and methods of manufacture from a disassembled component.

(c) Key/transferable skills:

On successful completion of this module, students should be able to:
- Articulate ideas and information in visual, oral and written forms;
interact effectively with others, working as a member of a small group/team;
- analyze information, formulate independent judgments and articulate reasoned arguments through reflection, review and evaluation;
- evaluate materials selection and possible manufacturing methods for a range of product types.

Contents:

Design of products for manufacture in practice by injection moulding involving investigation, design development, graphic communication through display modelling, costing, prototyping and evaluation. Design of an injection mould tool. Knowledge of prototype and commercial mould tool design. The development of 3D solid models using CAD systems. The post-processing of CAD solid model data to provide CNC output.

Introduction on mechanical and physical properties with practical examples to enhance the materials properties and product attributes or functions. Various key materials range from metals, polymers, ceramics and hybrid/composite materials are introduced with an emphasis on the unique properties of each material and the key factors that define their attributes. Key manufacturing processes from shaping, joining to surface treatment are introduced to students, including each one’s capability, economic impact, through case studies. Cambridge Engineering Selector will be used as a tool for students to understand and learn how to do materials and manufacture process selection using structural methodology. Practical laboratory work will be followed after classroom learning to consolidate students materials and manufacture knowledge, and more importantly to evaluate the materials and manufacturing processes used for any products under specific product context and to propose any alternatives could be chosen if product context is changed.

Note: This is the BA variant of the Design and Manufacturing Technologies Module. Its distinctive lies in the accessibility of the approach to materials and manufacturing technologies primarily aimed at Industrial Design students who have little background in this area.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Supervised time in studio/workshop</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>
Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:

Total student effort for the module: 300 hours on average.

Teaching and Learning: A combination of 13 one hour lectures (typically two per week), 6 CBE/3DAM development sessions (2 hours per week), 4 design development sessions (1 hour per week), 1 computer aided materials selection session (1 hour), 3 laboratory classes (2 hours per week), and 2 group tutorials (1 hour each). Remaining time to be self-directed study concerned with design development, product/mould tool manufacture, materials and assignments submitted/representation.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Weight</th>
<th>Exam Semester</th>
<th>Exam length</th>
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<tbody>
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<td>CAA Test 2</td>
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<tr>
<td>Computer based material assignment</td>
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<td>Coursework</td>
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<tr>
<td>CAD modelling design</td>
<td>10%</td>
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<tr>
<td>Group report - artefact analysis</td>
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<td>Coursework</td>
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</tr>
<tr>
<td>Design files</td>
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</tr>
<tr>
<td>Product manufacture &amp; presentation</td>
<td>35%</td>
<td>Coursework</td>
<td></td>
</tr>
</tbody>
</table>

100% coursework comprising: one design files (individual submission) 30%, and CAA Modelled Design (individual submission) 10%, one product manufacture and presentation (group submission) worth 30%, two CAA worth 10%, report in artefact analysis 10%, computer based material selection worth 5%.

This module will be taught predominantly in either Semester 1 or Semester 2.

Aims:

To develop knowledge and skills in physical and virtual prototyping, mechanical and kinematic systems, and product function simulation.

To extend the application of appropriate modelling methods as a means of combining and incorporating electronic and mechanical systems into the design of products.

To apply physical and virtual design applications in product realisation.

Intended Learning Outcomes:

Knowledge and Understanding:

On successful completion of the module, students should be able to demonstrate knowledge and understanding of:

- Physical computing and prototyping using MATLAB
- Design and development of electronic circuits via CAD
- Interaction design and Android mobile devices with App Inventor
- Basic theory behind mechanical systems, power transfer, stress, heat transfer, fluid flow
- CAD based mechanical simulation techniques including kinematic analysis, finite element stress analysis, thermal analysis and model optimisation
- Application of these techniques leading to the design of motorised, human-powered and suspension systems, heat transfer systems (eg heat sinks in electronics, roller devices, cooling fans).

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV103B1011</td>
<td>Physical and Virtual Prototyping in Design</td>
</tr>
</tbody>
</table>
b) Intellectual/cognitive skills:

On successful completion of this module, students should be able to:
- Apply a systems approach to design;
- Use scientific principles in the modelling and analysis of electronic systems;
- Use CAD modelling systems to simulate and analyse product function.

(i) Subject specific skills:

On successful completion of this module, students should be able to:
- Design interactive products;
- Use CAD simulation tools to design circuits and mechanical systems;
- Prototype and evaluate products in accordance with a P.D.S.;
- Write technical/laboratory reports.

(ii) Key transferable skills:

On successful completion of this module, students should be able to:
- Study independently, set goals, manage workloads and meet deadlines;
- Articulate ideas and information comprehensively in visual, oral and written formats;
- Use scientific evidence-based methods in the solution of problems;
- Apply scientific principles to the development of functionality in products.

Content:

Physical computing and prototyping, mechanics and product analysis as outlined in the intended learning outcomes.

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Practical classes and workshops</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Tutorial</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Guided independent study</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

Principally taught by: Design School

Module Code: 20
ECTS Credit: 10
Credit Level: 6
Exam weighting: 0
Pre-requisite modules: D506009, D506013
Responsible Examiner: Dr S J Guntesic
Delivery Period: Semester 2

Aims:

The aims of this module are for the student to:
- Explore and enhance design capabilities acquired in years 1 and 2 through appropriate industrial design activity;
- Utilise appropriate design research to enhance innovative industrial design activity to have the opportunity to enter an international student design competition;
- Generate high quality content for a personal design portfolio.

Intended Learning Outcomes:

1) Knowledge and Understanding:

On successful completion of this module, students should be able to:
- Demonstrate knowledge and understanding of methodologies of design research appropriate to understanding present and future user

2) Subject specific skills:

(i) Intellectual/cognitive skills:

On successful completion of this module, students should be able to:
- Analyse and evaluate user needs and emotional state of the user;
- Evaluate and synthesise research findings and user insights;
- Make evidence-based design decisions.

(ii) Practical/subject specific skills:

On successful completion of this module, students should be able to:
- Identify and evaluate potential project briefs and industry design activity;
- Manage and communicate design research findings to project teams and industry design activity;
- Generate and implement project plans and industry design activity;
- Engage with potential industry into an international design competition; generate appropriate material to justify design decisions; investigate present...
Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:

Total student effort for the module: 400 hours on average.

A combination of lectures (normally 60 minutes per week) and laboratory-based practical activities (normally two hours per week) for eight weeks in both semesters. Student project work will be formally supervised and supported for three weeks (normally 10 hours per week) in both semesters. Remaining time will be student self-directed study concerned with project development and presentation, assignments and examination revision.

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Report 1</td>
<td>20%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Report 2</td>
<td>20%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Report &amp; Presentation</td>
<td>60%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

100% coursework comprising: two laboratory reports at 30% each (one: 18 or 53), a project report/presentation (small group submission week 12 or 32) at 60%.

Method of Feedback:

1. Feedback given to students in response to assessed work:
   - Individual written feedback on coursework;
   - Feedback discussed as part of a tutorial;
   - Individual feedback on request;
   - Model answers

2. Developmental feedback generated through teaching activities:
   - Feedback on drafts / work plans;
   - Group critiques on work presented;
   - Studio, laboratory or field trip interaction with tutors;
   - Dialogue between students and staff in tutorials.

Teaching and Learning:

- Lecture: 5
- Tutorial: 10
- Guided independent study: 165

Total: 260

Teaching, learning and assessment strategies to enable outcomes to be achieved and demonstrated:

Total student effort for this module: 400 hours on average.

Weekly lecture/seminar sessions (6 to 3 hours per week). Remaining time to be self-directed study.

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>50%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

and future people-centred design issues.

> people centred design issues.

> future people-centred design issues.

1) Key transferrable skills:

On successful completion of this module, students should be able to:
- Understand and apply principles of design and creativity
- Conduct and analyze research data and information
- Formulate independent judgments
- Present written arguments through reflective, evaluative and evaluative.

Context:

- A lecture, tutorial, directed study, and design project module which explores the issues identified in the aims and intended learning outcomes. The topics will include: design research; user research; generation of insights from research data; concept generation and development; communication of research and design outcomes; identification of user needs; problem solving.
Method of Feedback:

1. Feedback given to students in response to assessed work:
   - Individual written feedback on coursework;
   - Feedback discussed as part of a tutorial;
   - Individual feedback on request.

2. Developmental feedback generated through teaching activities:
   - Feedback on drafts/ work plans;
   - Group critiques as work presented;
   - Stakes, laboratory or field trip interaction with tutors;
   - Dialogue between students and staff in tutorial;
   - Results of peer-marked tasks.

Course:

A visiting tutor will be appointed by the Design School.
The placement company will appoint an industrial or professional supervisor who will
be responsible for implementing the training programme agreed with the School.
The training programme will encompass as broad a range of work as possible with the student taking an increasing level of professional responsibility within the organisation.
The student will maintain a formal record of training and will be visited by an academic member of staff during the placement period (video conferencing facilities may be used for overseas placements).

Teaching and Learning:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Hours</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placement</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,000</td>
<td></td>
</tr>
</tbody>
</table>
Industrial Training Placement (DPS - non-credit) - 13DS1001

13DS1001: Industrial Training Placement (DPS, non credit bearing)

Principally taught by: Design School

Modular weight: 120
ECTS Credit: 60
Exam weighting: 0

SAP Restrictions: This module cannot be reassessed in SAP

Prerequisite modules: None

Availability: Module is available to students meeting pre-requisites but only if listed in their Programme Regulations.

Responsible Examiner: Dr. KJ Dodd

Duty Period: Semester 1 and Semester 2

Aim:
The purpose of the professional training within the course is to contribute to the student's preparation for a career in one of the many fields open to graduates of Industrial/Product Design and Technology.

Intended Learning Outcomes:
1. Knowledge and Understanding
   At the end of the professional training period, students should have knowledge and understanding of:
   - The role of the professional designer in industry and commerce
   - The responsibilities of the professional designer
   - Management and business practices

There are no mandatory final teaching arrangements for this module; students are expected to demonstrate appropriate personal development through the medium of work experience.

Assessment:

<table>
<thead>
<tr>
<th>Assessment Title</th>
<th>Weight</th>
<th>Assessment Type</th>
<th>Exam Semester</th>
<th>Exam Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coursework</td>
<td>100%</td>
<td>Coursework</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assessment is in three parts:
1. A 'record of training' log book submitted at the end of the placement.
2. A written dissertation/report of about 5000 words on a topic determined by the student in agreement with the company and the University Tutor. The work is to be submitted by the end of May in the placement year.
3. An oral presentation to a joint University/Company Assessment Panel.

Method of Feedback:
1. Feedback given to students in response to assessed work
   Individual written feedback on coursework

2. Developmental feedback generated through teaching activities
   Individual support, interaction and advice during the placement from the company supervisor;
   Comments on reports and draft reports by supervisor and visiting tutor;
   Written feedback following tutor visits;
   Personal and individual counselling on student's performance by academic and support staff by telephone and/or visits.
Appendix 16 – Validation study presentation, January, 2015

The full size presentation is also available in the Data CD attached.
LITERATURE REVIEW FINDINGS
Starting position established from the literature review findings:
The articulation of design thinking’s meaning has subtly changed since the 1980s
but the context of where it is being applied has dramatically transformed.

LITERATURE REVIEW FINDINGS
• Common Characteristics:
  Orient
  Subjects
  Input
  Process (OC)

RESEARCH INSTRUMENT DESIGN & PILOT STUDIES

PILOT STUDIES FINDINGS
• Tissue groups and seminars were dropped due to logistical and resource issues
• Updated visuals for key literature presentation
• Data gathered analysed by thematic analysis and content analysis
• Additional Common Characteristics were identified:
  "Design problems": traditional or non-traditional

DATA GATHERING
MAIN STUDY, JUNE - DECEMBER 2013
- Data collection methods
  - Semi-structured interviews
  - Online survey
- 2 data sets analysed
- 56 participants including 30 academics and 26 practitioners from around the world took part

DATA ANALYSIS

DATA ANALYSIS METHODS - THEMATIC ANALYSIS
- Thematic analysis
  - Flexible and adaptable
  - Summarizes large amount of qualitative data
  - Good for identifying themes
- Carried out in NVivo 10

THEMATIC ANALYSIS FINDINGS
Academics' consensus definition of design thinking:
A designerly approach to problem solving that can be used divergently to solve problems in any context and creates solutions by using suitable expertise and knowledge.

Practitioners' consensus definition of design thinking:
A collection of human-centred design-led problem-solving processes or approaches that address ill-defined problems in any context or discipline through creativity and focused questioning.

THEMATIC ANALYSIS FINDINGS
Similarities in academic and practitioner definitions of design thinking:
- Design process
- Problem context
- Problem solving
- Ill-defined or complex problems

THEMATIC ANALYSIS FINDINGS
Differences in academic and practitioner definitions of design thinking:
- User centered
- Creativity or creative thinking
- Experts or multidisciplinary
-协商
- Knowledge
THEMATIC ANALYSIS FINDINGS
Articulated consensus definition of design thinking:
Design thinking is a collection of design approaches and methods of problem solving that can be used in any context to generate solutions creatively by employing available expertise and knowledge.

DATA ANALYSIS METHODS - CONTENT ANALYSIS
- Content analysis
- 3 phases of coding
- Used to identify evidence
- Carried out in NVivo 12

CONTENT ANALYSIS FINDINGS
- 2 additional common characteristics identified from the data:
  - Multidisciplinary knowledge
  - Design thinking’s modes of expressions identified

DESIGN THINKING’S MODES OF EXPRESSIONS
- 5 modes of expressions identified from the data:
  - Graphonomy
  - Language
  - Numery
  - 1 + 1 = 2

DESIGN THINKING’S MODES OF EXPRESSIONS
- Matching the common characteristics with their modes of expressions:
  - Physicality
  - Process (ME)
CASE STUDIES ANALYSIS FINDINGS
Matching the 7 common characteristics and their modes of expression: a practice case study example:

- Design problems
- Traditional or non-traditional
- Multidisciplinary
- Knowledge (roles, etc.)

CASE STUDIES ANALYSIS FINDINGS
Matching articulated definition of design thinking with case studies findings:

- A collection of design oriented approaches and methods
- Problem solving in any context
- Generate solutions creatively
- Employing suitable expertise and knowledge

A QUALITATIVE DATA DRIVEN MODEL OF DESIGN THINKING

A QUALITATIVE DATA DRIVEN MODEL OF DESIGN THINKING

1. Definition
2. Defined by
3. Expressed by
4. Potential application: descriptive

1. A GENERIC DATA DRIVEN CONSSENSUS DEFINITION
Created from the research findings, validated via case studies analysis:

Design thinking is a collection of design oriented approaches and methods of problem solving that can be used in any context to generate solutions creatively by employing suitable expertise and knowledge.

2. DESIGN THINKING IS DEFINED BY...
the following 7 common characteristics:

- Design problems
- Traditional or non-traditional
- Multidisciplinary
- Knowledge

Drivers
Expans
Impact
Process (CC)
Appendix 17 – Validation study presentation guide, January, 2015

KEYS

Data collection methods used and evidence origins

- Literature review
- Interviews
- Pilot studies
- Online survey
- Data analysis (Thematic & content analysis)
- Case studies analysis

7 Common Characteristics (CC) of Design Thinking

DRIVERS were the external factors that kick started any project. Drivers kick started a project by either stimulating the identification of a problem or an opportunity. In the context researched an example of a problem would be that existing beach rescue watercrafts (paddle boards and jet skis) are inefficient in terms of deployment time and speed, which therefore affects the time and speed of rescue. The example was given in the practice case study ASAP Watercrafts. In the research context an example of an opportunity would be identifying an alternative application with existing technologies, such as the motion sensors used in the Nintendo Wii console’s controllers. This example was identified from the literature review (Vogus, 2006: 60 – 67).

EXPERTS were the people from different disciplines who were involved with the project because their expertise was required to help generate suitable solutions to the problem. In the context researched the following examples were identified as experts from a design project presented in the literature review (Brown, 2009: 186 – 188 & IDEO, 2019): product and service designers, Transportation Security Administration (TSA) security agents, airline staff at terminals and passengers. In addition to being examples of experts, this is also an example of possible constituents for a multidisciplinary team.

IMPACT was the result of using design thinking to solve the problem identified. In the context researched impact could be a new product created by using design thinking (an example would be ‘Mom’ the portable incubator which was one of the academic case studies researched); a competitive advantage over competitors; an unique selling point of a product (for example the Edge Max cutting feature on the Black & Decker lawn mowers researched in a practice case study); or increase in profit. These are just a few examples of what impact can be.

PROCESS(CC) were the strategies, steps or processes developed or used to solve the problems given. In the context researched, examples of process would be the ‘user centered design process’ or prototyping with CAD and 3D printing.

DESIGN PROBLEMS’, TRADITIONAL OR NON-TRADITIONAL described the nature of the problem identified. In the context researched, a traditional design problem would be designing a new range of power tools to increase the brand’s market share. A non-traditional design problem would be using design to increase the detection rate of potential terrors suspects at airports. The examples were identified from the literature review and case studies analysis.

MULTIDISCIPLINARY means the different disciplines that the experts who took part in the project belong to. In the context researched, an example of a project that was multidisciplinary was the TSA Security Checkpoint Evolution by IDEO from the literature review (Brown, 2009: 186 – 188 & IDEO, 2019). The disciplines where the experts came from were design, security and transportation.
### 7 Common Characteristics (CC) of Design Thinking

<table>
<thead>
<tr>
<th>KNOWLEDGE</th>
<th>GRAPHICACY is the ability to understand, read and create still visual images other than words, letters and numbers, as a means of communication (Baynes, 2013; Dancos, 2011). An example of that would be sketching.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAPHICACY</td>
<td>LANGUAGE is what people use to communicate with each other. An example of that would be a design brief.</td>
</tr>
<tr>
<td>LANGUAGE</td>
<td>NUMERACY is the ability to reason and apply numerical concepts. An example of numeracy being expressed in design thinking is the budget of a project.</td>
</tr>
<tr>
<td>NUMERACY</td>
<td>PHYSICALITY means the physical characteristics of an object that can only be expressed in 3D. An example of that within design thinking would be 3D printed prototype form models.</td>
</tr>
<tr>
<td>PHYSICALITY</td>
<td>PROCESS (ME) means a series of action directed toward a specific aim. An example of process being expressed within design thinking would be the “user-centred design process.”</td>
</tr>
<tr>
<td>PROCESS (ME)</td>
<td></td>
</tr>
</tbody>
</table>
Lancaster PhD seminar feedback 19th January 2015

Imagination Lancaster
00:00:00.00
I have one, I was wondering at the beginning of the research how did you set the disciplinary boundaries of your investigation in terms of what you use as case studies and people to interview? Because it seems very product design orientated.

Arthur Chan
00:00:33.23
Yes it is very product design orientated.

Imagination Lancaster
00:00:33.82
Yes it seems very product design orientated, I was wondering if that is a choice?

Arthur Chan
00:00:35.33
It is kind of a choice and my background as well because I did product design for my first degree and then I did a Masters in kind of design management and product design. Because of what Loughborough does and what the books get given to me. In terms of defending my thesis I chose product design case studies because I actually understand it. I can't defend something I don't understand so it is by choice and context as well. Does that answer your question.

Imagination Lancaster
00:01:17.68
Yes it does, I have one related. Do you think the model could apply to other design disciplines?

Arthur Chan
00:01:21.12
Well I like... I think maybe. I don't know until I try it in the field, I know it sounds like I am deflecting the question but I would love to test it outside other than just product design. I know the case studies are very product design orientated that is because of my background and where I come from. That is why I like to do more refinement on the model.

Imagination Lancaster
00:01:49.65
Sierra could I put you on the spot and you give an example of another design discipline?
Imagination Lancaster
00:01:57.98
The reason why I thought of that question was because of the Service Design Jam that you mentioned a couple of time. At certain points it did not seem to fit with the others.

Arthur Chan
00:02:04.18
No the Service Design Jam was an odd one. I tried to see if it fit, I know it does not fit. I make it sound like I am cheating! The Service Design Jam I used it because it was there, it happened and I used it and I thought it was a non-traditional design problem, because you are teaching a bunch of people who don't know design how to design. So I thought it would be interesting anyway to use it. The Service Design Jam is very artificial. Because it is three days you get given a brief and you pretty much do whatever you please in essence. But if it was a real service design agency it might work. The Service Design Jam was such a short amount of time so I think it was quite muddle up.

Imagination Lancaster
00:03:02.99
Yea because Service Design Jam is an event whereas if you take a service and you put it in that model it would work.

Arthur Chan
00:03:19.27
I did try get a service design case study but the person who promised me a case study moved after a week he agreed to it. It is one of those things. I think it could work for service design, graphic design touch and go, the others I don't know.

Imagination Lancaster
00:03:42.14
Sorry does that limit the whole field of enquiry of the study of the PhD that it ended up with one reason or another because focused on product design rather than design thinking in design?

Arthur Chan
00:04:00.84
I think I tried to make sense of it with product design. I think for now it is okay. To more forward I would like to open it up.

Imagination Lancaster
00:04:22.14
The other comment related to that is how you see impact.
Arthur Chan
00:04:33.88
I know impact was always going to be a debatable subject because of how everyone can see it. You properly see it very different from me and very different from those case studies show. For me impact was there because of all the literature suggestion, it was very heavily emphasised in the practitioners written ones. Even in the academic ones like the Nigel Cross book, the little Design Thinking book. He put it in a way that this is how you do a winning F1 car design. Impact was always going to be a bit of a problem but if I don't put it there then I can see someone saying why don't you have impact.

Imagination Lancaster
00:05:24.55
I see what you mean but the images and the product image that, the impact seems to be that it exists therefore it has impact. A prototype was created therefore the impact box is ticked. For me impact is the effect on the user or the user experience. What stand out to me like the Lumo, is it the Lumo? To me the impact is not the physical form but the impact is what impact it has on the children who are using it. So there is a bit an empty space for me. Clearly being an academic product or a student product there is no impact being measure. Again with the Service Design Jam there seems to be no impact and the impact does not count again is worrying in my mind because designing a service is just as valid if not more in some places. It is the whole kind of impact I think could do with a good look.

Arthur Chan
00:06:46.37
I know where you are coming from. I think I put down graphiacy and physicality for Lumo because I saw all the logbook and prototype and that was what was available to me. I did not see the testing of Lumo. Whereas the ASAP Watercrafts I know there is an impact, he went to Australia and got a load of beach rescue people to buy it. He told them it needs another year to get it produce and sign off but that is fine. They want to wait. In a way the other impact such as the tracking device which I did not use. The tracking device which is the little orange gun object. I have seen it work, in terms of him testing it I followed him a little and I saw it working but he could not test it with the emergency services. In essence I know if it was ever made at least the tracking bit works. There is an actual indication that the tracking part would work. He now works for IBM I don't know if it would ever make it into the market. I think in terms of the Mom incubator it is being develop now so it has the potential of saving babies life in refugee camps in Africa, he is going out to test it so... I know impact was a problem I guess I can only work with what I get given.

Imagination Lancaster
00:08:55.31
Everything has a limit doesn't it so recognizing that is a good indicator
Arthur Chan
00:09:07.24
I know impact is a problem. I know with the service design agency they were going to show me the banking apps on mobile. The firm did the Lloyds and HSBC mobile apps. They can talk about those two with me. I know what impact that has it made my life a lot easier because I happen to bank with both of them.

Imagination Lancaster
00:09:42.14
You chosen academic case studies that were just created now. If you look at academic case studies that were created five years ago and see if impact and to see what it did. So if it was done five years ago and it helped save some people life and it would help reduce travel times for ambulances and that is a recognisable impact.

Arthur Chan
00:10:21.79
For that I would have like to done that but within the known contacts that I have there was not any willing to talk. In terms of the perspective of identifying the common characteristics academic design projects were more suitable. I would have happily looked at something we did ten years ago at Loughborough but it would have taken too long due to the stakeholders and nothing might happen. Like I said I would like to refine ti more and have other people come in. Number 57 could kick everything into touch.

Imagination Lancaster
00:11:10.96
Would it help to think of it certainty in terms of evaluation process used in well programs and what not? So you use output, outcome and impact. Output would be the physical form, outcome is that it could be in production and impact is that it saved so many lives. A spectrum of impact.

Arthur Chan
00:11:41.24
Yes that could help, that would be something to work on. I would included that in my write up it is too late, well not too late to change but if I change it now I have to redo half of my Nvivo and end up losing my mind again. That could be included in the write up. Impact was something that was worked upon for a long time and just leave it as it is. I see where you are coming form

Imagination Lancaster
00:12:27.23
Other questions?
Imagination Lancaster
00:12:30.08
For the final model do you see it as a tool that can be use from.

Arthur Chan
00:12:31.85
It can be I think I cut you off early there, it can be used for...

Imagination Lancaster
00:12:38.73
For a company that suspect that they can do some design thinking...?

Arthur Chan
00:12:48.60
Yes that is why I have the modes of expressions. One thing you have the definition, we understand that now, these are the common characteristics and the modes of expressions will be there to help them to identify what they can do. One of the things I like to do and turn it into an evaluation tool. People can evaluate how much design thinking they can do. So for example we know the drivers and design problem but we don't have the other things so then they can go look for the other things. I guess it could help the modes of expressions are there and the potential application sequence. The application sequence is one of those things they could agree or not agree with. But it could be and I think because of the modes of expressions, under all the most of expressions there is a list of what they are and how to look for it. So with the modes of expressions people can check the list and say we can do that and that. We can do up to a certain point. It need further refinement. To turn into a evaluation I need to get more feedback.

Imagination Lancaster
00:15:13.95
Yea sure it might make sense to use it to evaluate process by someone who has no design experience, but a company that just create products and then actually be able to figure out it differ in that way and that is why we do it.

Arthur Chan
00:15:45.28
There is a potential to turn it into a evaluation tool but the first step is to get more feedback from it. Combine all the knowledge to get a generic guideline. Another thing I like to do and turn it into a self-audit tool for University as well. One of the ideas is that if we are leaders in design thinking the other is to turn it into a self evaluate tool.

Imagination Lancaster
00:17:20.29
I had a question it is about two of the common characteristics of design thinking.
It is about experts and knowledge. So reading here it said experts are people from different disciplines... Knowledge is provided... I guess my questions is is there an intent where experts do not provide knowledge? I can understand why one is a person, one is sort of a thing they use of have.

Arthur Chan
00:18:03.73
I think the difference here is actually shaped in terms of the literature evidence. I questioned that myself should I dig a deeper hole by combing them together as expertise? But if I call it expertise it would be harder to understand. Experts are people you do need people to do that. Knowledge and experts are spirited as they are because knowledge is a form of information for now. I properly need to come up with something better.

Imagination Lancaster
00:18:47.49
But do all experts have knowledge?

Arthur Chan
00:18:54.27
Yes they do but experts are there to tell people who they are...

Imagination Lancaster
00:19:02.89
Because the next thing is are all people design thinkers? Or only certain people are design thinkers?

Arthur Chan
00:19:16.19
Certain people are because if you said everybody is a design thinker then we have gone the complete practice viewpoint of what design thinking is. Everyone can do it as long as you have sticky notes... So not everyone is a design thinker. In order to do this properly you need the experts and knowledge. I think I need to skip that question for now and I would like to answer that. I did not want to mix it up with expertise because expertise in a way is even harder to define then I will come into question will all the social science people.

Imagination Lancaster
00:20:17.84
Does anyone else have a question?

Imagination Lancaster
00:20:30.65
It is complicated and in the end I find it. I have read one of the books on the presentation, the Tim Brown one. How is the final model you draw out is
distinguish from the others? You mentioned design thinking is not different, not changed.

**Arthur Chan**
*00:21:09.83*

It is distinguished because it is data driven.

**Imagination Lancaster**
*00:21:14.71*

Maybe did you not hear my question. You draw out a model, you referred to literature review and this model is related to product design maybe it cannot fit another type of design. What is the characteristics that make your model distinguish maybe form the other modes they used before they used in design thinking? Did you find something new and referring to the other people who were defining design thinking before.

**Arthur Chan**
*00:21:57.83*

Yes mine is actually a combined view of academic and practice whereas the others. So that is why I call it data driven and it was created form data collected of the past fifty years. Whereas I guess the other ones they have was more of a single vision of what they had or did. This is not just me, I believe in it, in a way but I can only believe so much in it by what I found out with my research. The way is shaped by data. It is not just shape by what I said.

**Imagination Lancaster**
*00:22:55.75*

So many it is more empirical research behind it.

**Arthur Chan**
*00:23:03.52*

Yes it is more empirical research behind it then designer A said that and this is it. What I did is look at the differences and similarities. Despite the differences these seven things are there so we can make some sense of it by understanding it. I know it is product design heavy at the moment.

**Imagination Lancaster**
*00:23:44.36*

Does anyone have anything else? I have one last question. At the beginning you show the literature review you show the right hand side the book you read. Most of those books where from the discipline of design. Did you find from the literature of the 1960s that other disciplines were talking about design thinking? I know what you are saying were about application in management and business. I wonder if people were talking it in another time.
Appendix 19 – Practitioner validation study transcript, January, 2015

DT Model Feedback

VP1:
00:00:00.00
What you have not done is looked at fashion, textiles, architecture, graphic design and illustration. It would be nice to look outside the area of product design, just to see what others have to offer.

Arthur Chan
00:00:29.85
I see where you are coming from I came from a product design background. If I did those things and I did not understand them fully I might find it hard to defend in the viva.

VP1:
00:00:39.70
But you might find some surprising similarities. They might highlight aspect of product design you haven't considered.

Arthur Chan
00:00:55.50
I think this would be the limitation of my study that is quite product design bias. I know it sounds like an excuse it is just where I came from. Because we are in the Design School etc... That is why for future work I would like to take it out there and see what happened. This was something that was highlighted in Lancaster as well, they were like is that not a bit limited and then I explained my background, they were like okay. Something that everyone seems to be interested in. Another other thing you would like to mention?

VP2:
00:01:45.07
If I were to comment on, the reason I asked what use is it. If this is for students to use and help their critical thinking and designed thinking I find it quite confusing separating things out in this way. It does not feel intuitive to me at all. I can recognise the bits and pieces but I found it difficult to follow.

Arthur Chan
00:02:36.50
I think improvements can be made on...

VP2:
00:02:44.02
It seems so abstract, would you agree with that word?

VP1:
00:02:51.09
Yea but it does not cover abstract thinking perhaps... There were all those other slightly fuzzy areas, so much of design for me is about identifying the right problem to solve to begin with. For me we always start at the process of a memories of the design journey. I think the journey start way before identifying the problem and the research taking it outside, what is the right problem to solve? Now you got your right problem really clearly defined; design process is actually quite technical problem solving exercise towards the end. Initially I was thinking if that was incorporated into some marking scheme like for the RSA projects then oh my God!
Arthur Chan
00:04:01.83
I don't think it will be ever, or at this moment I don't see it as a marking scheme. Do you guys have any issues with the common characteristics? You mentioned that I separated the elements and made it hard. Do you believe the common characteristics actually made it harder to understand?

VP2:
00:04:32.04
It is not... in separating it out this way... It is not part of my knowing. I recognised these things in the processes. Separating them is like rather explaining a joke. The moment you take the joke apart... It is very complex why we would find something funny but in explaining it you lose the humour... So much of design is all our experiences and we bring so much in we are not conscious of and indeed our biases like your product design bias. Doing it in this mechanical way seem to miss out on that special thing from the heart, that individual thing that you bring to it and make it rather cold and clinical.

VP1:
00:05:52.38
Even compartmentalisation is what I am also struggling with. The reduction of some of these compartmentalise subject area you chosen could be PhD subjects in their own right. They are also trivialised here. They were very limited in the way you summarized them and limited in the way of what they mean.

Arthur Chan
00:06:33.64
Did the modes of expressions helped at all?

VP2:
00:06:43.06
Helped what?

Arthur Chan
00:06:45.01
Helped in make sense of the common characteristics.

VP2:
00:06:47.30
Common characteristics of design thinking...

VP1:
00:07:01.87
Design thinking modes of expressions you are asking about...

VP2:
00:07:04.25
So this is the way design thinking is communicated.

Arthur Chan
00:07:13.66
Yes.

VP1:
00:07:18.10
At what stage in the process we are talking about.

Arthur Chan
At any stage so I got the drivers, which is expressed by numeracy and the jet skis are too slow...

**VP2:**
00:07:50.68
It make sense but again you are missing something there by splitting it up like this. The jet ski got to where it is because of who is driving it. The way he looks characteristics and his personality. It think that is why it is successful because of a charming guy driving it.

**VP1:**
00:08:09.61
Like Dyson I suppose

**VP2:**
00:08:12.36
Yes there is that. There are elements of this in someone's persona and charisma. I suppose language is a big part of that in how to express it. I suppose it is not the only part.

**VP1:**
00:08:24.91
When we are talking about modes of expression who are we expressing these modes or who is receiving these modes of expressions?

**Arthur Chan**
00:08:42.67
The people who use design thinking or who is trying to use design thinking or understand design thinking.

**VP1:**
00:08:50.82
No I mean, that would be the people who are interested in your PhD. When you think design thinking's modes of expressions who is the recipient of that modes of expression within this process. Are we talking about a client, a user, someone in the PhD study. As a designer communicating graphically, I don't like the word graphicacy. Who am I talking to then.

**Arthur Chan**
00:09:42.15
If you are communicating with graphic then it will be the end user or the client.

**VP1:**
00:09:48.75
That is what you mean by the recipient of these modes.

**Arthur Chan**
00:09:55.00
Yes it could be expressed by any of these modes. That is just methods.

**VP2:**
00:10:06.46
Where is the 7 common characteristics? There are one two three four five six...

**Arthur Chan**
00:10:09.95
Seven is on the back. So you are saying splitting the common characteristics
makes it harder to understand because I am trying to make something organic mechanical?

**VP2:**
00:11:10.61
Yes you are taking apart something that is fluid and that is my criticism.

**Arthur Chan**
00:11:23.53
Yes that is fair enough. I just have not heard from it form that point of view. I guess maybe it is because maybe when you do a PhD. I think there are some people said it make sense. I know where you are coming from. Or maybe this PhD prove you can't explain it.

**VP2:**
00:11:57.15
As an output it would be nice to have a list of ways of communicating, sometimes the skill is to choose which is the best at any given situation or who is going to warm to what.

**VP1:**
00:12:27.58
I think these are also very generalised I think that can be a massive subject area that can be explained on.

**Arthur Chan**
00:12:49.68
That is just the key I have thousands of words in my thesis to explain it.

**VP2:**
00:12:55.35
You highlighted the product that tried to heal broken families. It is a non-traditional design problem because it is a social problem.

**Arthur Chan**
00:13:20.40
I know what John said is correct it could have been another other thing rather than a product, but we don't do that here. In another University it would have been a service probably. I looked at it because that was that one which was solving the kids having issues with separated families. There was another one with a research tool for design researchers which I did not understand. This one make sense so I could dig further. The Service Jam was non-traditional as well.

**VP2:**
00:14:12.27
So what define a traditional design problem?

**Arthur Chan**
00:14:19.39
A traditional could be... using the Black and Decker because they did not have the domestic use. In order to get more market share they need a home range.

**VP1:**
00:14:41.31
I guess coming from an outsider into Loughborough. Most of the projects coming out of the 3rd year the students try to innovate. I guess what this does not cover is if you are dealing with a mature object.
Arthur Chan
00:15:17.05
You said mature object?

VP1:
00:15:17.05
Yes so mature objects like a chair, chopping board, knife etc... You can do very beautiful things with mature objects without doing this innovation process. In Loughborough innovation is a big driver isn't it? You must innovate, you must do this and that. You never do anyone do any mature objects. But that is fine that is the slight bias of the University and you don't seem to address that aspect of design.

Arthur Chan
00:15:53.58
The innovative aspect of design?

VP1:
00:15:53.58
No the mature objects of design, where perhaps it requires a lot more artistic treatment and sculpting of the products.

VP2:
00:16:06.38
I always think of a range of products ranging from needed like a scalpel blade; very basic to wanted for something you don't need but something that is so beautiful that you want to buy. I just want this in my life. And in between you have the I want to believe it type where like a Dyson it express this scientific efficiency like best performance or whatever. So are you saying that we don't do enough of the beauty and exploration of the ascetics of products?

VP1:
00:16:49.09
I suppose so. I would like to do more of that. The department is very much focused on this user centred design process to create an object that does not exist in the market.

The solution to that is always a product. A good example of that is this product for the kids in separated families. The solution is to create an electronic product or a consumer product. I like to see a lot more of the beautiful part of sculpting, dealing with materials and tiny design twists on existing products. Maybe just as creative, in fact it is more difficult to improve the design of a mature object than invent something. It would be nice to see some element of that. I guess this seems to be where it is lacking. Maybe looking at contemporary fine artist and seeing how they are creating their work could help. In fact it is quite simple if you look at Grayson Perry Channel 4 show he used a lot of design research process and thinking in that way. User research, user observation technique, reflecting on society, it would be worth looking at just to see how a fine artist is using all these design techniques.

VP2:
00:18:56.69
Going back to the seven common characteristics of design thinking, something I have been trying to separate now, what I do now. I think it comes to a point that when I design I take step back and look at the design to see if that is something that moves you, makes me want to buy it. All objects have a
voice, you are trying to address the feel and if it is saying the right thing. Does that come under impact? That sort of gut feeling. Whether you feel something is right or wrong. That is my sort of design thinking, you got to work out if it is right or wrong. You got to work out that magic thing if the right proportion, if you pick it up does it feel good.

Arthur Chan
00:20:03.40
I guess it could come under impact.

VP1:
00:20:07.26
This seems to describe if it for-fill a design problem. It is more at what you describe at impact.

Arthur Chan
00:20:16.42
Is the more emotional side of things...

VP1:
00:20:18.59
Yes all the products we buy and surround ourselves with are expressions of ourselves and personality. The house you live in, clothing you wear and sometime that is quite a subconscious thing and it is quite hard to measure.

Arthur Chan
00:20:40.29
I know what you mean by that I think that is quite hard to put across is that sort of context.

VP2:
00:21:00.12
Just add the X factor here! To not mention it maybe there is a box over the question mark. Magic box.

VP1:
00:21:00.12
That would be the holy grail wouldn’t it!

VP1:
00:21:18.47
Again I think design process is something that is quite fluid and changing and evolving. Rather than pinning it down so rigidly at a tick box.

Arthur Chan
00:21:36.17
Oh I know that hence I put it down as a potential application sequence because I knew someone would come along and say it is wrong. I am not going to say I know it is wrong I can only work with what I get given. I suggest it could be express in such a way if you think it is wrong then lets go further improve this.

VP1:
00:22:05.98
Just thinking about textiles and perhaps fine art there is a way of working in that field that you don’t know what is going on. Like when an artist is creating a sculpture.

Arthur Chan
I guess that is the fuzzy front end.

VP1:

There is a kind of fuzzy area where you are experimenting using all your personal experience, you don't know why and it almost happen in a subconscious way. This happens in textiles, fine art and even fashion. A lot of fashion project starled off like that.

VP2:

Certainly a lot of the students don't get that. A lot of my projects I start thinking I can never do this, can't think of anything, but it is not until you get through that bit you sort of let accident happen. Sometime accidents turn into something special.

Arthur Chan

That accident part is mentioned a lot in the books. They say fail early if you want to do design thinking. So if you don't fail you can move forward. I think it is hard to define what the fuzziness with all the experiment stuff is. I guess what I am trying to do here is put something on paper and get a better understand this.

VP1:

I think it is good that as designers we look ourselves what is going on here.

Arthur Chan

I remembered when I was doing things and I don't know why I did it. When you give someone a bucket of Lego and people start making things. It is not something that is said out loud is it, it just happens.

VP1:

I suppose it is not something like if you follow this set of processes you are going to get a good design out of it.

Arthur Chan

I think that will then depend of the expertise and knowledge and who is using it. I would like to test it more. I guess this is a first step towards something. This is the end point for the PhD and something to move forward to.

VP2:

My criticism of using this as a blueprint in design school or university is that it could foster the believe of I have ticked all on the list give me full marks. But you have the job to say this is not exciting, doesn't move me not special. What I want to see is something from them that I could have never come up with.

VP1:

What we are talking about is the fuzzy bits.
VP2:
00:27:30.23
I know why Universities and schools like this because it is easier to access and make sense. It is harder for students to take criticism when you cannot explain it. Sometimes it is hard to explain. I think it is very Loughborough, in Nottingham Trent there is a more fluid approach. Loughborough like to compartmentalised things, I think the way the course developed and people do their own thing. It does feel very compartmentalised at a point.

VP1:
00:29:43.55
The drivers examples are very much based upon a user centre approach or need rather than historical context or social reflection. Or something more abstract.

Arthur Chan
00:29:56.54
I think I did it without even knowing!

VP1:
00:29:04.67
You have been conditioned.

VP2:
00:29:09.78
Brain washed

Arthur Chan
00:29:12.99
I didn't know! I guess I have been brain wash

VP1:
00:29:35.48
So much of design I guess is step back see the whole picture without being bias and that is a really hard thing to do. You see a lot of the students they blinker without their problem solving and they don't look in a broader sense that gives you those surprising results. That is what disappointing.

VP2:
00:30:09.74
I guess the example would be the big Play Station controller thing... For me yea I am sure it is brilliantly engineered.