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Towards a holistic framework of design competence.

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This article focuses on the development of a holistic competence framework that highlights the relationship between knowledge, attitude, skill and capability within the field of design management and design-led innovation. Whilst individual expertise in the aforementioned attributes are important to individual performance, it is argued that becoming an expert in design ultimately originates from a combination of these attributes and the ability to apply them in any given context.

The article derives a framework through a systematic review of the design competence literature, before applying this framework to a case study based on a postgraduate design project. The case study provides an insight into the competence held and developed by individuals at a postgraduate level multidisciplinary design-led innovation practice course, providing a foundation for future study in the area. The framework is capable of mapping the transition of competence from the novice designer to an expert who has mastered the ability to apply competence to any given context and as such offers a unique insight into design competence, given that current models primarily focus on education alone with little discussion of transition into design management, design-led innovation and its practice.

***Keywords**: Design competence; Design knowledge; Design skill, Design attitude, Holistic competence.*

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1.0 Introduction

Contemporary organisations are facing complex, open-ended challenges that require leaders to broaden their range of thinking in order to develop strategies capable of dealing with these problems (Stacey, Griffin, & Shaw, 2000). 'Multidisciplinary teams are becoming increasingly prevalent as their variety of knowledge, resources and perspectives is suggested to enhance the ability of the organisation to deal with such challenges' (Reuveni & Vashdi, 2015, p.678). Despite this, within multidisciplinary collaboration, the discipline of design can often be misunderstood by other disciplines due to the implicit and deeply held beliefs that are central to the nature of design knowledge; which is often intangible, yet provides designers with the capability to propose novel solutions to complex problem situations.

Studies seeking to understand the attributes of individual designers within the context of both multidisciplinary teams and organisational leadership vary in their approach to achieving an understanding, however many studies centre on the notion of competency development. Despite this, current studies within design research have struggled to arrive at a consistent definition of the term 'competency', with several studies viewing it purely as a basic set of design abilities. These abilities are often not specific to the field of design and as a result only offer a slight insight into the value that design can offer above other disciplines in relation to problem solving. This is particularly important for studies that are seeking to research design practice within organisations, where design can face difficulties in highlighting the value that it offers outside of traditional product creation (Conley, 2004).

The aim of this paper is to consider the types of competency framework that are suggested across design literature in order to arrive at a framework that is capable of offering an insight into the uniqueness of design within multidisciplinary contexts. The framework will then be applied to a multidisciplinary postgraduate education context, in which the students completed a project with industry clients in order to create innovative solutions to an existing complex problem situation. Through this, it is hoped that a suitable foundation for future research will be provided, in which it will be possible to explore in detail the attributes that underpin the work of successful design leaders.

The article is structured as follows: first, relevant literature is reviewed, discussing current models of design competence and exploring the need for further frameworks. Subsequently, a holistic competence framework is proposed and explained, outlining the individual areas in which designers possess attributes related to competence. Next the methodology is described in relation to outlining specific examples of competence that are related to the proposed framework within the context of a postgraduate innovation project. Finally, conclusions are explained, providing contributions to theory in addition to highlighting opportunities, limitations and recommendations for future research.

2.0 Design Competence

According to Berge et al., (2002) the term competency initially stemmed from a belief that clearly defined competencies would systematically ensure effective job performance within the context of an organisation. Many different definitions of competence have evolved from this starting point, resulting in a range of definitions and frameworks that have been derived within different fields; yet not all of these definitions are compatible and as such there is still much debate surrounding the nature of the term. Riches and Saganik (2001) offer a broader definition of the term, stating that a competence is the ability to meet complex demands by drawing on and mobilising psychological resources in a particular context. An insight into the psychological resources required for competence can perhaps be found in the definition offered by the European Centre for the Development of Vocational Training (Cedefop, 2008), who state that a competence is not limited to cognitive elements (involving the use of theory concepts or tacit knowledge); it also encompasses functional aspects (involving technical skills) as well as interpersonal attributes (involving social or organisational skills and ethical values).

Similarly, within design research there are a variety of studies that tackle competency development, however there is little consensus towards a universal definition of the term. Subsequently, two contrasting schools of thought have emerged and have been termed ‘the reductionist’ and ‘the holistic’ view of design competence (Kovačević, 2008). The reductionist view is nothing other than a basic set of design abilities typically addressed

individually, whereas the holistic view sees design competence as a synergetic construct of generic human capacities (ibid).

2.1 The reductionist view of competence

The reductionist view is common within design management literature, with authors such as Hardin, Westcott and Berno (2014) using this approach to highlight the necessary competence that new designers need to develop in order to successfully transition into effective design managers in the future. Their proposed competency framework includes attributes such as: leadership, communication, collaboration, visualisation and storytelling. Røise et al. (2014), also adopt this viewpoint in an investigation into the competence of industrial designers. They create a taxonomy that includes teamwork, creativity, project management, and visualisation amongst others in order to create a map documenting common perceptions of design competencies. Whilst these attributes are no doubt important to design management, it can be argued that they meet Conley's (2004) criticism of many competence studies, in that they are generic and do not necessarily capture the essence of what designers really do.

The reductionist view is perhaps more appropriate to studies of education in disciplines where the focus is on a collection of knowledge that students need to recall in order to pass exams. In contrast, the focus within design education is on framing a collection of knowledge within a broader set of capacities that are also needed in order to deal with an increasingly complex set of problems. As a result, the holistic view of competence is perhaps more relevant to understanding the competence of design leaders, as it is capable of highlighting the broader set of competencies that are necessary in order to deal with the complexity of design problems.

2.2 The holistic view of competence

In contrast to the reductionist view, the holistic view sees competence as a mix of various attributes combined into a coherent framework. The aim of these frameworks are primarily centred around ensuring that a more complete model of professional development can be produced in comparison to the more simplistic reductionist models (Cheetham &

Chivers, 1996). Le Deist and Winterton (2005) suggest that generally, the notion of competence is being broadened to capture underlying knowledge and behaviours rather than simply functional competencies associated with specific occupations, however it appears that this transition is still occurring within the field of design.

Nelson and Stolterman (2012), propose a framework of competence within design learning that centres around four domains of design learning: design character, design thinking, design knowing and design action or praxis. It is suggested that these domains combine to form an axis of dichotomies that must be achieved in order for one to become a designer. They indicate that the responsibility in learning to be a designer is the challenge of maintaining this knowledge set over time by continually discarding and renewing content as necessary. It is suggested that the role of design education is to ensure that these domains are brought together at the right time, in the right proportion, in the right environment, managed by the right people in order to become an interconnected temporal whole, producing a competent design professional.

Horváth (2006) proposes a different framework centred around the concept that design competence is a synergetic construct of five generic capacities: capabilities, attitude, knowledge, skills and experiences. The key proposition to this framework is that equal emphasis must be placed on each capacity in order to develop well-rounded designers capable of applying this competence to a wide range of contexts. Whilst this framework goes some way towards creating a model for design competence, by the authors own admission the investigation was limited in scope and many more things need to be investigated in order to have a validated theory of comprehensive design competence development. In particular, the framework does not consider the difference between generic constituents of design competence and the specific needs of design tasks in relation to driving innovation within multidisciplinary teams.

Furthermore, both of the aforementioned examples of holistic competence frameworks revolve around design learning and education and do not consider the way in which a designer's competence is shaped outside of education, throughout various stages of expertise. This is also a prominent issue with the reductionist approach, highlighted by Miller and Moultrie (2013) who indicate that little is understood of the skills needed by

individuals who are responsible for leading design. It is this gap that this paper aims to address, building on the framework proposed by Horvárth (2006), in creating a framework that can be applied to education, but can also be applied to practice in order to map the differences between individuals in both contexts. It is expected that this would be of interest to both educators and practitioners of design, by highlighting the relationship between competencies across both domains.

3.0 Towards a holistic competence framework for design innovation

The previous sections have discussed the key differences between reductionist and holistic competency frameworks, however they highlight a lack of consensus towards a suitable framework in the field of design innovation. Holistic frameworks appear best suited to describing the competencies of design individuals as they contain many aspects that are discussed in the reductionist frameworks, yet offer further possibilities in explaining the uniqueness of design in comparison to other disciplines. In order to arrive at a consensus regarding the components of a competency framework, Appendix A outlines an in depth view of existing frameworks including the various components that constitute the framework as well as the context in which each framework was derived. Some of the frameworks are derived from a professional development context, which are seen to offer an insight into the general competencies that are needed by people in the workplace, whereas other frameworks are more specific to the design discipline, exploring the factors that lead to the success of individuals in the field. Holistic frameworks have the potential to bridge the gap in existing theory within design research, however they appear more common within general professional development literature as opposed to design research.

From this review, it is proposed that a holistic framework comprised of knowledge, skill, attitude and capability demonstrates the potential to provide an insight into the competency of designers, when considered alongside the level of experience that a person has in each aspect. Each of these aspects are seen to be mutually interactive and as a result, they are difficult to separate as seen in typical reductionist frameworks. Appendix B visualises the relationship between these specific aspects of competency,

which will be further described in stages throughout the remainder of section 3.

3.1 Knowledge

Like competence, the term knowledge often holds multiple connotations and interpretations (Augier & Vendelø, 1991). The way in which knowledge is defined is directly related to the way in which it is both developed through education and managed within organisations. Knowledge can be defined as data that is collected, processed and/or elaborated in the past and integrated into memory, which then plays an important role in problem solving (Visser, 1995). Cross (2006) summarised design knowledge as comprising abilities of resolving ill-defined problems, adopting solution focused strategies, employing abductive reasoning or appositional thinking and using non-verbal modelling media.

Within design research, there have been several attempts to classify design knowledge with many of these attempts typically pairing contrasting types of knowledge (Biggam, 2003; BonJour, 1985; Grayling, 2003; Neuweg, 2002; Rodgers & Clarkson, 1998). Niedderer (2007) conducts an in depth review into knowledge types and concludes that the most important knowledge pairs when conducting design research are the two pairs of tacit and explicit knowledge and propositional and non-propositional knowledge. Whilst other knowledge types can offer important distinctions within their fields, to discuss every term of knowledge in detail is beyond the scope of this work. Subsequently, within this work, the focus will remain on the pairs of tacit and explicit knowledge and propositional and non-propositional knowledge, which appear to be the most important pairs within design research.

Tacit knowledge is commonly defined as knowing more than we can tell (Polanyi, 1958). It is impossible to articulate and is intuitive, forming part of an individual's cognitive thought and perception (Suppiah & Sandhu, 2011). Subsequently, tacit knowledge is difficult to share, with the results often being slow, costly and uncertain (Wang, Ashleigh, & Meyer, 2006). Despite this, Davenport and Pruask (1998) outline that the value of sharing tacit knowledge is so great that it can be critical to an organisation's success. With regards to an organisation's innovation capabilities, Nonaka and

Takeuchi (1995) identify that successful innovation within organisations directly stems from the mobilisation and conversion of tacit knowledge, therefore the tacit knowledge held by design leaders will form a critical part of their overall leadership competence.

Contrastingly, explicit knowledge is often referred to as codified in that it can be expressed using formal language. It is organised 'according to a clear and known system and can therefore be written down or transmitted verbally with little or no interpretation on behalf of the sender or receiver' (Nylund & Raelin, 2015. p.534). Teece (1977) indicates that within organisations, explicit knowledge is typically transferred through manuals, reports, user interfaces and guidebooks. Generally, explicit knowledge with regards to innovation capacities is less useful in providing organisations with a competitive advantage, as explicit knowledge tends to be easily available to competitors and therefore much easier to replicate than tacit knowledge (Cavusgil, Calantone, & Zhao, 2003); however it is still an important feature within the innovation process, with Smith (2001) indicating that organisations that are capable of recognising a wealth of tacit and explicit knowledge and utilising it to achieve goals have a major competitive advantage. Subsequently, it is also important to consider the explicit knowledge held by design leaders, due to its relationship with the tacit knowledge that they possess.

Whilst the tacit and explicit knowledge pair is formed to distinguish knowledge by the characteristic of communication, propositional and non-propositional knowledge is a distinction concerning the nature of knowledge. Propositional knowledge is knowledge that can be expressed in declarative sentences and is knowledge of something rather than knowledge of how to do something (Gemma, 2014). For example, a person being able to recall the contents of a textbook would count as propositional knowledge, however they may not be able to apply this knowledge to solve a problem based on the contents of the textbook. Non-propositional knowledge contrasts this, in that it is acquired by directly carrying out a task.

With regards to design leadership, propositional knowledge relates to the education that people receive in that it is acquired through conservative forms of learning. Non-propositional knowledge is perhaps more relevant in that it relates to the experiences that design leaders have and their ability to apply their knowledge to problem solving. Lawson and Dorst (2009) echo

this, finding that knowledge within design tends to be more 'episodic' than 'semantic'. Episodic memories include: events in our lives, things that we have seen and done and places that we have been. Subsequently episodic knowledge is the type of knowledge that is largely generated through a person's experiences. Osland *et al.* (2001) refer to this process as experiential learning and builds on Kolb's learning cycle (1985) to explain that experiential learning typically occurs through four phases: concrete experience, reflective observation, abstract conceptualisation and active experimentation. The application of experiential knowledge to problem solving within the field of design ensures that more attention is given to finding the right problems to work on, problems are adequately defined, better solutions are found and a more effective implementation process is followed. Subsequently knowledge is an important attribute when solving design problems, however knowledge alone is not enough to ensure that a person is in a position to utilise the knowledge that they possess; according to Kirschner *et al*. (1997), the person in question also needs the necessary skill, which will be discussed further in the next section.

3.2 Skill

Singley and Anderson (1989, p.2) characterise skill as 'the application of knowledge to a task', which is closely related to non-propositional knowledge, where the user of cognitive skill is carrying out a higher order process with any knowledge gained. Unlike knowledge, skill is difficult to acquire in a short space of time, therefore there is an extensive variance between the skill set of a novice designer and the skill set of an expert. Skill sets often require extensive practice to master, a view expressed by Gladwell (2008) who discusses several psychology studies that highlight that the practice of a skill for a duration of time (approximately ten thousand hours) ultimately leads to the level of mastery associated with being a world-expert of that skill. This is echoed by Posner and Keele (1973) and Sennett (2008) who argue that skills within craftsmanship (inline with the intuitive approach of design) are hardly ever developed in a single attempt. Sennett (ibid.) claims that skills provide the foundation of a craft, with the novice being problem attuned transitioning to an expert who is capable of utilising skills by fully feeling and deeply thinking about what they are doing. Skills are therefore an important construct within any competency

framework, in that they are essential for the application of knowledge to a context, yet they are also extremely dependent on experience and practice.

3.3 Capabilities

Design capabilities are general personal qualities that are needed by people in order to develop design competence. They are natural capacities that allow people to act as designers and they can take many forms, such as: intelligence, imagination and creativeness. Reynolds and Snell (1988) identify these capabilities as being both generic and high-level, proving to be crucially important in both the acquisition and reinforcement of skills. Yeung and Ready (1995) advocate capabilities as one of the central components of competence within organisational leadership, suggesting that a strong set of capabilities is critical for the leadership of global corporations in which organisational structures, processes and systems struggle to cope with complex business environments. Consequently, well-developed capabilities provide a sound base for the development of the other areas of competence and are therefore important in the development of strategic level leaders.

The development of capability is fundamentally different to knowledge and skills, in that it is much more difficult to be taught. Brown and McCartney (1995) express that people are capable of acquiring knowledge and task specific skills through on the job training or participation in formal education, but the efficient application of these attributes is dependent on capabilities which cannot be so easily taught. This poses a challenge to educators and designers seeking to improve the capability aspect of competence, as it is a complex and difficult area to address directly. Horváth (2006) suggests that design capabilities can be developed in a similar manner to other innate physical and mental human capabilities, however this process typically requires many years of difficult focused learning and practicing. The time taken to develop capabilities suggests that they are a key differentiator between people of varying levels of experience, with experts likely to be in a position where they have had years to develop these capabilities, as opposed to a student fresh out of university who has not spent an equal amount of time with a focus on learning and practice.

3.4 Attitude

A design attitude is a unique mind-set and approach to problem solving that allows designers to shape inspiring and energising designs for products, services and processes that are both profitable and humanly satisfying (Boland & Collopy, 2004). A decision attitude contrasts the design attitude, and is prominent within management education. It assumes that it is easy to derive solutions to a problem, but it is difficult to make the correct choice among them. On the other hand, the design attitude assumes that it is difficult to develop a good solution or alternative to a problem, however, when you design a great solution, the decision about which alternative to select becomes trivial. The design attitude appreciates that the cost of not conceiving a better course of action is often much higher than making the 'wrong' choice among them.

Key elements of a design attitude are questioning of basic assumptions and a resolve to leave the world a better place (Carlopio, 2010). Designers relish the lack of predetermined outcomes and they tend to approach new projects with a desire to experiment with materials, technologies and methods and to do something differently and better than ever before. To do this, designers must work creatively within the established boundaries of a project and each project must be approached with a desire to experiment and do something differently and better than ever before (ibid). Michlewski (2008) suggests that attitudes will likely differ significantly between professionals from different fields, such as: product design, accounting, operations, management and marketing. Subsequently, a design attitude is an entity that is capable of differentiating design from other disciplines, meaning that it should be a prominent feature in any competence framework.

3.5 Experience

It is important for any competency framework to consider the way in which competencies are developed through both learning and practice, over time. To do this, it is worthwhile adopting a model of experience that is capable of documenting the stages of skill acquisition that people follow. Perhaps the most extensively utilised model of skill acquisition is provided by Dreyfus and Dreyfus (1986) who suggest that there are five stages in the

human skill acquisition process, with an individual transitioning from novice to expert with increasing exposure to skilful practice (visualised in appendix C).

Criticisms of the Dreyfus model are offered by Lawson and Dorst (2009) who highlight that design is an activity that is not restricted to people that have undergone formal training, or on occasion even realise that they are designing. Despite this criticism, the Dreyfus model appears to be a useful model in explaining a designer's development as their experience increases. Dorst and Reymen (2004) indicate that the Dreyfus model takes the development of skills as a starting point for a model of learning and expertise development, which is closely linked to the way in which design competence is developed through education and practice.

3.6 Summary

To summarise, the framework highlights that skill, knowledge, attitude and capability are interconnected capacities that combine to explain competence within design. Previous frameworks that adopt the reductionist approach do not provide a full picture of design competence, whereas holistic approaches are better positioned to do this. The framework derived in this paper suggests that as people acquire experience through practice, their competence increases. Ultimately people who are experts in the field have the ability to take their competence and apply this to a problem in any given context. Next the framework is applied to design education, utilising a case study of a postgraduate design project.

4. Methodology

The methodology for this research utilised qualitative methods in the form of a workshop to determine the learning that occurred through a postgraduate design project. The chosen design project centred on a social innovation issue and lasted three weeks from the initial project briefing to the delivery of concepts. Fourteen students from a multidisciplinary design postgraduate programme at a UK University took part in this research, having completed this project at an earlier date. Participants in the

workshop worked in the same teams that they were in for the project for the first three activities and were then asked to answer questions individually for the final two activities.

The workshop commenced with the students documenting a timeline of the project to provide a template for the workshop questions. Wording of the workshop questions was critically important in gaining as full a response as possible without offering solutions or leading the students in any way. In determining the skills and capabilities that were used throughout the project, students were asked to use the timeline to write down the corresponding skills that they felt they used at each stage of the project. Students were not told about the distinction between skills and capabilities at this stage, with the distinction being drawn by the researcher in the analysis of the provided data. This was appropriate as it ensured that students were focused on the output of the question, as opposed to the wording of two similar questions. Students were then asked to rank the skills that they improved most throughout the project, to determine which skills were present before the project and which were specifically developed throughout the project.

In order to determine the knowledge utilised throughout the project, the students were asked to choose three key decisions that they made throughout the project and then explain the knowledge that underpinned these choices. This allowed them to ground the notion of knowledge within a context that was easier for them to understand, instead of asking them to explain the knowledge that they drew from throughout the project. Finally, in order to determine attitude, participants were asked about the aspects of the projects that they found stimulating and the aspects that they found irritating. This was derived from Michlewski's work (2008), which focuses on design attitude, with the expectation that participants who had a design attitude would find similar aspects of the project engaging.

Using Benner's (2004) evaluation of the Dreyfus model of skill acquisition, the participants as postgraduate students are considered to be transitioning between the stages of advanced beginner and competent. Consequently the results outlined in the following discussion relate directly to design competence at that particular level of experience. Further study is required to apply the framework to the remaining levels of experience in

order to fully understand the development of competence from education into practice into mastery of the subject.

5.0 Discussion

The following section will discuss the findings of the workshop in relation to the framework categories.

5.1 Knowledge

Several of the decisions made during the project were underpinned by the knowledge of outside 'experts' who provided students with feedback of their initial concepts. Experts varied from tutors to industry contacts and often had a large influence on the decisions that students made. It is expected that this is something unique to people who aren't yet proficient in a craft, in that they are recognising the knowledge of people with more expertise and using it as the basis of crucial decisions. It is likely that people proficient in using design tools for problem solving would hold the experience necessary to make most decisions without seeking the knowledge of others to underpin choices made. Experts in particular would not rely on the knowledge of others in this manner. Consequently this could be unique to teaching environments, where people are in the process of learning the skills that they need to solve design problems in a wide range of contexts.

The students involved in the project also relied on experiential knowledge derived through previous projects, particularly in relation to research methods that were adopted. The students had awareness from previous projects of the benefits of a survey methodology in relation to the type of data that was needed for this particular project as well as the timescale being compatible with the timeframe of the project. They were able to draw from past experience to apply methods in a new context, which is an incredibly important aspect of design knowledge.

Finally, one group in particular recognised that they were having difficulties in the idea generation phase of the project, stating that they felt

'stuck' in the process and that they found it difficult to progress. Through working on other projects, they were able to establish that they were having difficulties quite early on in the process and as a result were able to seek out alternative strategies to help them through the problem that they faced in creating new concepts. Through experience of delivering projects the group were able to identify that part of their process was not working as fluidly as it had in the past and therefore applied this knowledge to the problem at hand.

5.2 Skill

The design specific skills utilised by the students in this particular project revolved around several categories: communication, bringing ideas to life, concept development, problem framing and user centred approach. Bringing ideas to life includes skills such as prototyping (3D, rapid), sketching and visual communications. These skills typically revolve around the development of concepts through a medium in which tactile learners are more confident in expressing their ideas. They are extremely common tools utilised within design, however they are not often seen in any disciplines outside of the wider category of design.

In terms of skill improvement over the course of the project, communication between multidisciplinary team members was highlighted as one of the major changes. Sennett (2012) describes this communication process as dialogic, looking at new situations in a problem-finding manner. This skill was identified as being particularly important in the initial stages of the project, in exploring and framing the problem. This type of exchange is perhaps specific to design in which problem finding is core to the discipline and a specific aspect of team communication. Innes (2007) suggests that dialogic communication is also central in the construction of experience and useful knowledge, making it an important tool in connecting skills to other aspects of this framework.

Developing a user centred approach to problem solving was also highlighted as one of the key areas of improvement throughout the project. This is both core to the discipline of design and unique to the discipline, making it an important aspect developed through the project. Students used

a variety of skills within this area, including empathy, customer profiling and segmentation of potential markets.

5.3 Capability

The capabilities frequently utilised throughout the project centred on the themes of project management, people management and justifying decisions in relation to specific criteria (e.g. stakeholder analysis and making a business case). Capabilities focused around working with others were also featured prominently throughout the workshop, with capabilities such as managing client expectations, networking, negotiation and patience appearing to be relevant to several stages of the project. Students had to manage the relationship with clients from the beginning of the project and utilised methods such as negotiation in dealing with this. These capabilities were therefore crucial in the execution of the project, however they are not especially unique to the discipline of design. Despite this, whilst these are not design specific capacities, they are extremely important in reinforcing the design specific skills outlined in the previous section.

5.4 Attitude

The design attitude revolves around the way in which designers approach and feel about problems. The students who engaged with this particular project found the brief itself to be stimulating, allowing for the creation of a wide range of concepts with the students being given "complete creative freedom" over the process. Stimulus was also found in the presenting of ideas and concepts to clients at the end of the project. This aligns with Boland and Collopy's (2004) expression that when people with a design attitude believe that they have created a truly innovative solution to a problem, the decisions to implement that idea become incredibly straight forward.

A design attitude was prominent amongst all of the students that took part within the research, particularly amongst those who had formal design backgrounds as opposed to other multidisciplinary teammates. This suggests that the development of a design attitude is something that can occur quite early on in the skill acquisition process. Viewing problems in this manner is

something that is likely to be common between the postgraduates that took part in this particular project and any expert designers that approached the same project.

6.0 Conclusion

To summarise, there are two key schools of thought within the design competence literature, the reductionist and holistic view. Reductionist frameworks view competence as a basic set of design abilities and are often not detailed enough to give a comprehensive view of design competence. The holistic view aims to correct this in viewing competence as a combination of various human capacities working together in synergy. The framework proposed in this paper considers competence to be made up of skill, knowledge, attitude and capability. The competence held by a designer is dependent on the level of experience that they have in each of these capacities.

Next, the paper provided a picture of design competence through the lens of a postgraduate design-led innovation project carried out at a UK university. It was found that the students relied on the knowledge of 'experts' in making their decisions, as well as making decisions based on experiences from similar projects carried out in the past. Design specific skills were prominent in the areas of communication, bringing to life, concept development, problem framing and a user centred approach. Particular improvements were seen in the development of a communication style that was problem finding. General capabilities were prominent in the interactions of people, with the managing client expectations found to be one of the key areas of improvement. It was also found that at this level of experience, people were capable of having a design attitude in their approach to problem solving. It is likely that this approach is common from an early level of skill acquisition.

Framing design competence through a holistic approach has implications for the way in which design is taught, practiced and managed. Design management education must look at the different aspects of competence to ensure that students are acquiring the broad range of competence necessary to transition into successful practice, rather than primarily

focusing on skill development. Meanwhile, design managers may also find this framework useful in facilitating reflection, in an attempt to fuel the personal development of themselves and others. The suggested competencies all play a role in the practices of innovation, therefore a deeper understanding of competency will allow better management of the people involved within innovation processes, particularly when it comes to making decisions based upon the strengths and weaknesses of a team. To further enhance these findings, more extensive research is needed to align the competencies developed within this case study to other postgraduate programmes in order to build a more comprehensive picture of design competence.

There is room for future research into the competencies held by those already in practice, particularly those considered to be experts in their field. Again, this will provide a more complete picture of competence across both education and practice. It is suggested that the framework discussed in this paper will prove to be a suitable template for this research. Furthermore, the use of workshops to facilitate reflection in this instance proved particularly useful in creating a discussion surrounding the explicit knowledge that the participants had developed throughout the project, however the primary limitation of the approach is that it is impossible to uncover much in the area of tacit knowledge. It is suggested that a workshop technique be applied alongside a method such as repertory grid interviews (Gribbin, Young and Aftab, 2016) in order to provide a more complete insight into the knowledge that is utilised and developed throughout project based activities.

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Appendix A

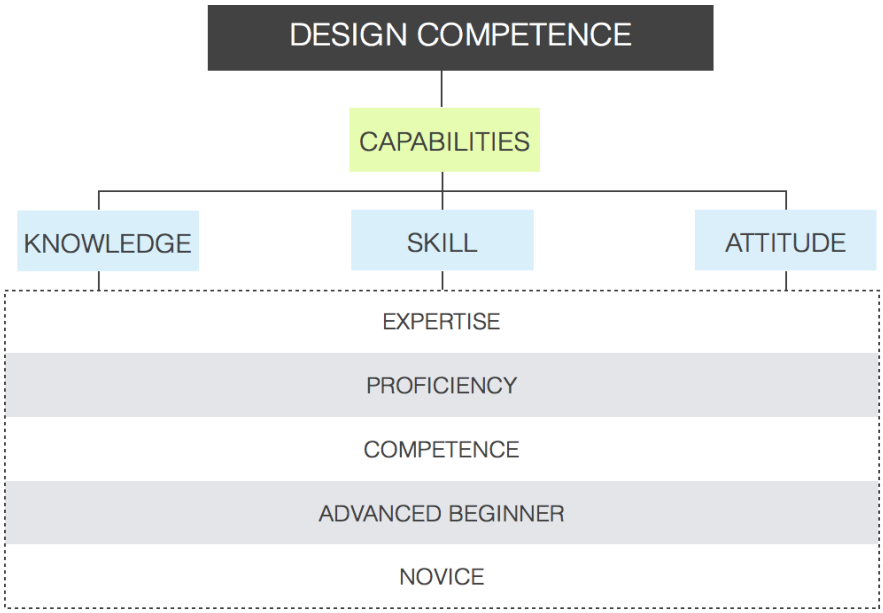
Reference	Type of framework	Context/field	Components
Ho and Hsu, 2015.	Reductionist	Digital content creation.	Layout design, understanding of user-interface principles, integration of different publishing formats and specifications, use of various editing software to create layouts, use of animation to create special effect images, utilising storyboarding techniques, conducting film editing.
Hardin, Westcott and Berno, 2014.	Reductionist	Graduate education for design management/leadership.	Leadership, self-awareness, collaboration, entrepreneurial/innovative attitude, communication, facilitation, visualisation, teaching, storytelling, maker mentality, culture making.
Røise *et al.*, 2014.	Reductionist	The professional competencies of industrial designers.	Teamwork, creativity, specific design methods, users, market, project management, aesthetics, holistic design approaches and methods, visualisation, technology, functionality, use, context, ecology.
Cheetham and Chivers, 1996.	Holistic	Professional education and development.	Knowledge/cognitive competence, Functional competence, personal or behavioural competence, values/ethical competence, meta-competencies.

Le Deist and Winterton, 2005.	Holistic	Training and development initiatives.	Cognitive competence, meta-competence, functional competence, social competence.
Nelson and Stolterman, 2012.	Holistic	Design practice and learning.	Design character, design thinking, design knowing, design action or praxis.
Horváth, 2006.	Holistic	Design practice	Capabilities, attitude, knowledge, skills, experiences.
Hummels and Vinke, 2009.	Holistic	TU/e industrial design competencies within education	Continuous learning, descriptive and mathematical modelling, integrating technology, ideas and concepts, form and senses, user focus and perspective, social cultural awareness, designing business processes, design and research processes, teamwork and communication. Under the banner of meta-competencies, knowledge, attitudes, skills, traits and characteristics.
Miller and Moultrie, 2013a.	Reductionist	Fashion management	Envisioning, designing, understanding, communicating, empowering, driving, planning, selecting, challenging, coordinating, optimising, directing, integrating, protecting, evaluating.

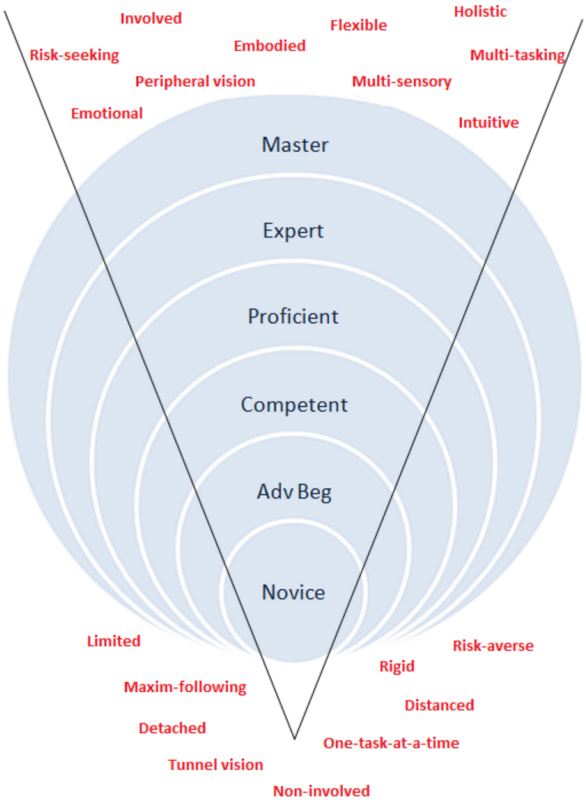
Miller and Moultrie, 2013b.	Reductionist	Design leaders	Cognitive skills, interpersonal skills, business skills, strategic skills.
Conley, 2004.	Reductionist	Design within business enterprise	Understanding the context of a design problem and framing it in an insightful way, working at a level of abstraction, visualising solutions, simultaneous creation and evaluation of solutions, maintain value as pieces are integrated into a whole, the ability to establish purposeful relationships among elements of a solution between the solution and its context, the ability to use form to embody ideas and communicate their value.
Spencer and Spencer, 1993.	Holistic	Human competence	Know-how task skills, transferable skills/ abilities, values, standards, etiquette, judgement, motives, work ethics, enthusiasm, self-image.
Godbout, 2000.	Reductionist	Knowledge management within human resources practices	Performance orientation, team leadership, conceptual skills, analytical skills, self-assurance, initiative.
Angeles *et al.*, 2011.	Holistic	Design engineering	Established skills for design engineers, attitudes towards design engineering, specific knowledge in a professional environment, knowledge of procedures.

International Board of Standards for Training and Performance Instruction, 2005; in: Chyung *et al*., 2006.	Holistic	Professional development	Knowledge, skill, attitude.
National Centre for Education Statistics, 2002.	Holistic	Education/competency based learning	The combination of skills, knowledge and attitude to perform a specific task.

Appendix B


DESIGN COMPETENCE
CAPABILITIES
KNOWLEDGE
SKILL
ATTITUDE
EXPERTISE
PROFICIENCY
COMPETENCE
ADVANCED BEGINNER
NOVICE

Appendix C



(Rolinska, 2011)