

Cognitive Apprenticeship in architecture education:  
Using a scaffolding tool to support conceptual design

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award of the degree of Master of Philosophy (ICTs in Education)

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## Abstract

Modeled on the master-apprenticeship relationship, student designers gain access to implicit design knowledge mainly through the conversations with their tutors during studio projects. However, intimate design studio tutelage is being challenged by increasing student to staff ratios. If leveraged effectively, technology offers the potential to maximize tutors' time investment in order to allow them to tend to more students. Scaffolding tools (Reiser, 2004) as supplement to teacher support, can assist learners with complex tasks previously out of their reach.

This case study is a critical realist inquiry into the use of a scaffolding tool, Cognician Cogs. It seeks to reveal the ways in which and circumstances under which these Cogs scaffold conceptual design in a second year architecture studio project. The study draws upon Cognitive Apprenticeship as a conceptual framework to shed light on design studio practices involving specially developed Cogs. The mixed methodology approach adopted consisting mainly of qualitative data in the form of the project brief, scaffolding tool content, sample design critique conversations and interviews with three tutors and nine students. Supplementary quantitative data included closed survey question responses and Studio work marks collected from the entire class (39). Thematic analysis of the qualitative data was framed by the Vitruvian guiding principles of architecture: 'Firmness', 'Commodity' and 'Delight'. The study revealed that the intended use of the Cogs to cover aspects of Firmness and Commodity only resulted in the over-scaffolding of Firmness and the under-scaffolding of Delight. The students' resulting designs were practically acceptable, but lacked novelty.

*Keywords:* scaffolding tools, cognitive apprenticeship, conceptual design, architecture education

To Carlton who would have been an exceptional architect.

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## Chapter 1. Introduction

### 1.1.Overview

In South Africa the onus of making quality tertiary education affordable amidst a challenging economic climate is high on the agenda (Daily Vox, 2015). The architecture design studio also finds itself at this “cross-roads” (Morkel, 2011, p. 222; Tzonis, 2014, p. 76). Modeled on traditional apprenticeship, the pedagogical practices in the studio are very different from the traditional face-to-face lecture. Architecture tutors rely on dialogue to convey implicit design knowledge. However, the time-intensity of the design critique conversation between tutor and student make it economically unviable. Asynchronous technology tools offer learning conversations flexibility and more time for student reflection (Conole & Dyke, 2004). Bender (as cited in Walpole, 2012) says: “Technology is transforming the practice of architecture and design from the conceptual stages right down to the actual construction”(p. 1028). Oxman (2006) proposes that technology tools offer the added benefit of acting as catalyst for explicating implicit architectural design knowledge.

Percy (2004) documented the migration of design studio students to technology platforms. She blames limited studio space and industry pressure for software proficiency. She also highlights that students themselves are “pushing the agenda of independent learning” (p. 144). Leveraging the flexibility affordances (Bower, 2008) of technology allows them the economic benefit to work and study simultaneously.

According to Morkel the integration of technology into the design studio is warranted especially as means of supporting and extending face-to-face design conversations. She cautions however that it does not automatically imply the development of the necessary architectural “critical thinking and design conceptualisation” (2011, p. 222) and proposes the

redefinition of practices in the architecture design studio should coincide with technology integration.

### **1.1.1. Context and rationale**

This study is set in the Architectural Technology & Interior Design Department at a South African university. The department offers a National Diploma (NDip) in Architectural Technology and a Bachelor of Technology (BTech) in Architectural Technology. Similar to other architecture education institutions, the context is challenged by “worsening staff-to-student ratios” (Morkel & Voulgarelis, 2010, p. 1). A senior lecturer in architecture, Tutor A, explains that this impacts on duration and frequency of lecturer-student feedback. Valuable face-to-face time is also often wasted on addressing students’ basic procedural queries, with less time spent on scaffolding students’ conceptual design skills (personal communication, July 19, 2013).

During the period of the research Tutor A was a subject lecturer for Studio work in the NDip. Tutor A was also involved in the redesign of the specific programme in 2010. Changes were implemented to address “the economic crisis, requirements of human capital in the information age, changing architectural practice and advances in ICTs, such as online tools and social media, and research on design-build methods” (Morkel et al, 2013.). Figure 1.1 depicts changes made to the second year programme of the NDip during its redesign in 2010.





Figure 1.1. NDip Architectural Technology redesign (Morkel et al., 2013, pp. 3)

As seen in Figure 1.1, prior to the redesign of the course in 2011 the NDip’s learning contexts were limited to on-campus ‘studio learning’ and ‘workplace learning’ (experiential learning in architects’ offices). In both contexts learning activities happened face-to-face only. Two new learning contexts were added in 2011, namely “workshop learning” (in orange on Figure 1.1) and “service learning” (in green on Figure 1.1). More significant for this study was the introduction of the “technology-mediated online learning” (at the centre of Figure 1.1) to the context, evolving the NDip from a face-to-face to a blended learning programme. Online tools incorporated include Facebook, Skype, course and student blogs (Morkel et al., 2013, 3-4).

Tutor A was completing her DTech on ‘Exploring the online learning conversation for conceptual architectural design’, building on the work of Brown, Collins and Duguid (1989). She deduced that there are three types of conversations that occur in the architecture design studio: the vertical conversations between tutor/lecturer and student; the horizontal conversations between student and peers; and the student’s internal conversation. After

establishing that the latter is fairly unexplored and might potentially support Tutor A's research, the context and focus for my study was demarcated. Tutor A decided that my potential research project also provided the opportunity for her to act on a longstanding intention of collaborating the self-coaching platform, Cognician. She met the Cognician founders in 2010 and discussed the potential of using Cognician's software in this context as a viable solution that could support architecture students' conceptual design process.

My hope is that the results of this study will be of value to Tutor A, the blended learning programmes in this specific architecture department and to the team at Cognician.

## **1.2.Cognician Cogs**

Cognician is a software platform that supports a user's process of exploring a topic. It guides the user through an interactive question-and-answer process inspired by the Socratic Method. Questions are grouped in themes and packaged in smaller applications called 'Cogs'. Cogs are short for "conversational guides" and comprise questions and supporting content in the form of text, images or video organised around a theme or topic (Worthington-Smith, 2015). Atagana suggests that Cogs are useful to "guide you through complex intellectual tasks that require either critical and systematic thinking or creative, imaginative thinking, or a blend of both" (2011, February 2). The software interface resembles a social media chat space, but the conversation is not synchronous but scripted. Figure 1.2 lists all the features of a Cognician Cog.



Figure 1.2. Anatomy of a cog

In this research project the *chat avatar* indicated as number 1 (#1) in the infographic above (Figure 1.2) represented Tutor A, in a scripted online conversation between her and individual students. *Prompt(s)* (#2) are questions and statements designed around a theme to guide students to consider certain aspects, in this case pertaining to their design of a pop-up shop. The *user's response field* (#3) provides a text block where students type out their answers to question prompts. The tutor's question prompts and answers are referred to as a *worksheet* (#4). *Insights* (#5) are responses that students can choose to share to a forum visible to their peers. Worksheets can be *saved* (#6) and completed at a later stage or *exported* (#7) as an html or text file. The *review feature* (#8) allows administrators or developers to improve the cog. The *sidebar* (#9) provides dynamic just-in-time content that can include formats such as text, images, video or slideshows. The *dynamic prompt feature* (#10), which incorporates information from a previous response to further personalise the cog conversation, was not utilised for this specific studio project.

### 1.3. Studio project overview

The design problem set for this curriculum project in which the Cogs were used was a tourist-focused pop-up shop for a remote missionary village (Wupperthal). Students received a project brief and worked through five cogs to support their conceptual design. Photos from the project shown in Figure 1.3, from left to right, show the project brief, Cog landing page and user interface.



Figure 1.3. Project brief, Cog landing page and Cog user interface

Students then formulated their design intent (plan) as sketches and phrases, as seen in as Figure 1.4. They also discussed this intention in a design critique conversation with their tutor.

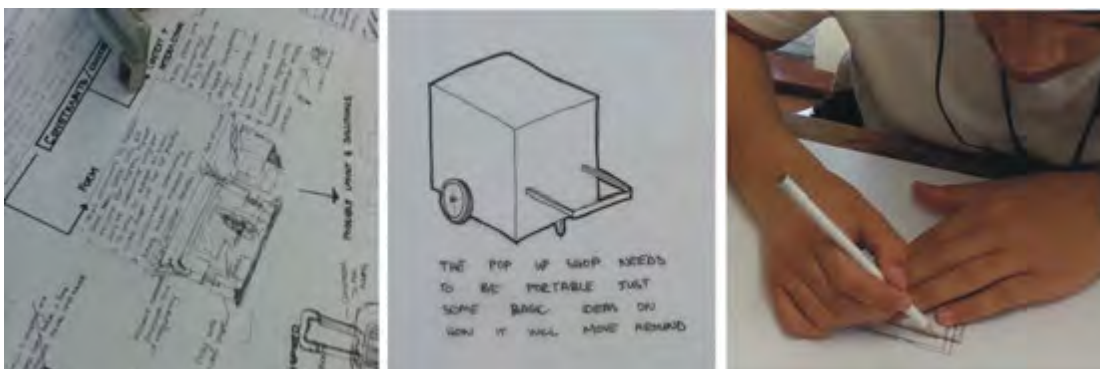
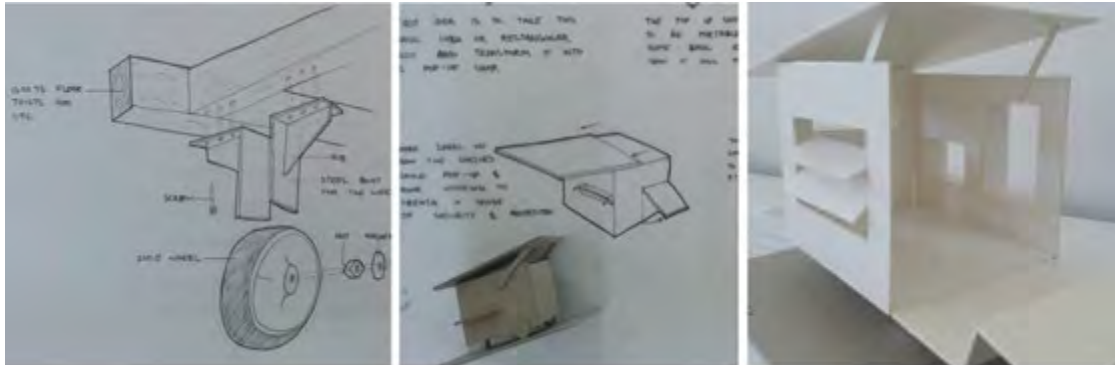


Figure 1.4. Design intent sketches

Towards the end of the project sketches became more detailed, building up to the final artefact for submission, a three-dimensional model of their design, as shown in *Figure 1.5*. This part of the project, however, falls outside of the scope of this study.



*Figure 1.5.* Detailing sketches and three-dimensional models

#### **1.4. Research questions**

The research question that frames this enquiry into the use of Cogs in the design studio project is:

In what ways and under which circumstances does the use of a scaffolding tool (Cognician Cogs) support architecture students' conceptual design?

Subsidiary questions:

- What was the influence of the Cogs on student outcomes?
- What did the Cogs contribute in scaffolding Firmness as a guiding principle of architectural design?

- What did the Cogs contribute in scaffolding Commodity as a guiding principle of architectural design?
- What did the Cogs contribute in scaffolding Delight as a guiding principle of architectural design?
- What role did the Cogs play in students' formulation of the design intent?

### **1.5.Theoretical framework**

Following on the work of Morkel et al. (2013.), Hokanson (2012), Conanan and Pinkard (2000) and Törnqvist (2011), this study employs Collins, Brown and Newman's (1989) cognitive apprenticeship (CA) as its theoretical lens. CA proposes the explicated depiction of the implicit aspects of expertise to help novices develop complex problem-solving and conceptual thinking skills.

In CA a learning environment comprises four dimensions: content, methods, sequence and sociology (Collins et al., 1991). This study includes selected CA concepts, namely domain content, heuristic strategies, scaffolding as CA method, and global before local skills as a sequencing issue.

### **1.6.Introduction to Research Methodology**

This research examines the use of Cogs during the early design stage of a studio project. A critical realist position (Bhaskar, 1975) informs the case study (Sayer, 2008) approach and mixed methodology (Creswell, 2015) provide a differentiated, in-depth, complexity-sensitive portrayal of the event.

Primary research took place through qualitative data analysis of the project brief, Cogs, sample design critique conversations, and interviews with three tutors and nine students. A

process of thematic analysis (Braun & Clarke, 2006) was conducted in Excel to categorise the qualitative data according to the Vitruvian guiding principles of architecture (Wotton, 1624), namely Firmness, Commodity and Delight. I was a non-participant observer in the studio sessions, and my observations were incorporated to gain initial insights into possible tendencies in the qualitative data set. Quantitative data from the whole architecture class in the form of Studio work marks and responses to closed survey questions provided supportive evidence. As this study involves human subjects, the University of Cape Town (UCT) Humanities Ethics Guide was adhered to. First the research proposal was approved by the Research Ethics Committees of UCT and the institution used as research site. Permission was sought from all participants and their inputs were treated in a confidential manner. Transcribed interview scripts were presented to participants for feedback.

### **1.7.Thesis structure**

This chapter provides an overview of the research, background to the study, the rationale, research questions, theoretical framework and research design.

Chapter 2 reviews relevant literature on architecture education, conceptual design, scaffolding in the design studio, scaffolding tools and the research frameworks CA (theoretical) and the Vitruvian guiding principles of architecture (analytical).

In Chapter 3 I explain and justify the research design and methodology used in the study. The discussion includes the reasoning behind the participant selection, choice of methods, instruments and data analysis. This chapter also considers issues around validity and ethics relevant to the study.

Chapter 4 presents and discusses the selected research findings on the use of the Cogs in an architecture design studio project.

Chapter 5 provides a summary of the research findings, reflections on the research, recommendations and implications for future research.



## **Chapter 2. Literature review**

### **2.1. Architecture design**

To compose a single definition for ‘design’ is nearly impossible (Lawson, 2005). Attempting this feat has split architecture design theorists into roughly three camps: those who see the architectural design process as “making”, those who called it a “reflective practice”, and those who align with the notion that it is “rational problem solving” (Feast & Melles, 2010, p. 1). In a more elaborated categorisation Muhammad (2009) compared five architectural design process models and concluded that the only similarity is that they all start with a brief and end with a design. Lawson (2005) contracted the design process into the same two elements, the problem (contained in the brief) and the solution, which according to him stay together, reflecting each other. This dissertation does not include an extended discussion of the concept of design, but takes, as a point of departure, Rowe’s pragmatic definition of architectural design as a “fundamental means of inquiry by which man realizes and gives shape to ideas of dwelling and settlement” (1987, p. 1).

### **2.2. Architecture education**

Architecture education was founded on the master-builder-apprenticeship model. Prior to formal schooling, apprenticeship was the natural way to learn. During the Renaissance the French government formalized architecture education with schools such as the Ecole des Beaux-Arts (Cret, 1941). The Beaux-Arts’ pedagogy revolved around students solving design problems under the intimate tutelage of those who were considered to be brilliant teachers. Tutoring and learning by doing were the two core ingredients in the Beaux Arts method (Lackney, 1999). By the nineteenth century the popularity of the Beaux Arts grew, and the use of the apprenticeship system to school architects declined (Cret, 1941). The Bauhaus school in Germany opened in 1919 and challenged the French method of architecture

instruction. The Bauhaus school embraced modernity: mass production, technology and employability. In contrast to the Beaux Arts, the instruction method used combined training in technical skills, work experience and practical tests (Lackney, 1999).

Oxman (as cited in Turkienicz & Westphal, 2012, pp. 2) proposes that there are three concepts in present-day architectural design pedagogy used either individually or in hybrid form: the ‘Beaux Arts atelier or studio system’, the ‘laboratory of design exercises’, and the ‘studio based on design reasoning and design strategies’. The laboratory of design exercises was classically used in the Bauhaus system. Design exercises that students undertook were experimental and based in the “Montessori methods of sense education” (Cross, 1983, p. 50), resulting in the development of innovative shapes and forms. Oxman (as cited in Turkienicz & Westphal, 2012, pp. 3) suggested establishing a studio based on explicit design knowledge, reasoning and strategies, and Turkienicz and Westphal (2012, p. 3) christened this the “cognitive studio”.

### **2.3.Design studio**

Learning in the design studio is at the core of the architecture curriculum (Kurt, 2009) and is both project- and problem-based (Kuhn, 2001; Morkel & Voulgarelis, 2010). Learning how to design is situated in the act of designing itself. This learning-while-doing methodology shifts the learning from the epistemological to the ontological (Heylighen & Neuckermans, 1999). Brown (2006, pp. 5-6) refers to this as “learning to be”.

An open-ended design problem is typically presented in a design project brief, which initiates the design studio project. Students advance through a number of cycles of iteration during this process while they develop their design, first as a sketch and then as a three-dimensional model. Students are encouraged to use a variety of appropriate media forms and tools as part of their design process. Tools could include online search engines and books, and graphic

representation tools such as AutoCAD<sup>1</sup> or Sketchup<sup>2</sup>. Students also draw upon design precedents (provided or their own) which inform their design thinking. Studio projects are set in a critique space (Burroughs et al, 2009). Tutors, peers and experts provide frequent feedback on work during students' design processes (Kuhn, 2001).

Design studio education has been hailed as an inventive pedagogy for broader project-based education (Brown, 2006; Schön, 1984a). Brown suggests that it is the “learning to be” (rather than “learning about”) (2006, pp. 5-6) that makes learning in the studio unique. He calls for wider use of what he believes to be a successful learning model for the 21<sup>st</sup> century, while Schön (1984a) highlighted the value of studio-based learning particularly for vocational education. Studio learning has become a more popular pedagogical approach in the last couple of years. A prime example of its rising popularity is the more than 40 work-integrated studio-schools established in the United Kingdom since 2011 (Harrison, 2013).

### **2.3.1. Design studio pedagogical issues**

Oxman (1999) admits that in architecture education the studio system is successful mostly due to the amount of individual attention that students receive. She does, however, also allude to the flaws in the studio. She stands with Lawson (2005) and Philippou (2001) in highlighting that the culture in the design studio is preoccupied with creating a design product, neglecting the process thereof. Lawson says that “students, in paying so much attention to the end product of their labours, fail to reflect sufficiently on their process” (2005, p. 7).

For Oxman the “pedagogical distance” (1999, p. 106) of the tutor is a crucial challenge in the design studio; teaching and learning is based on the intuition of both tutors and students and design knowledge is implicit, while the foundational knowledge about design is ignored and

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<sup>1</sup> [http://study.com/what\\_is\\_auto\\_cad.html](http://study.com/what_is_auto_cad.html)

<sup>2</sup> <http://www.sketchup.com/about/sketchup-story>

left to be gained implicitly through design activities and experience. Turkienicz and Westphal point out that in the studio expectations pertaining to the management of “programmatic, functional, economic or context dependent constraints” are quite clear, while procedures relating to the “creative process, architectural language or individual style” (2012, p. 1) are not. Oxman calls creativity the “black-box of creative design” (1999, p. 106) in the design studio. Williams and Askland allude to the similarity between the common definitions of “design” and “creativity”, both seen as disciplines seeking “a balance between form and function, between originality and practicality, novelty and appropriateness” (2012, p. 9). Although there seems to be a high value placed on the presence of creativity in the design product, it is most often neglected in the pedagogical process (Oxman, 1999; Turkienicz & Westphal, 2012; Williams & Askland, 2012).

A 2008 study of architectural education in Australasia by Ostwald and Williams (as cited in Williams & Askland, 2012, p. 4) pinpointed out the lack of understanding how to teach, recognize and assess creativity as key issues for architecture educators and that both students and faculty experience trauma due to the nebulousness of creativity in the design studio.

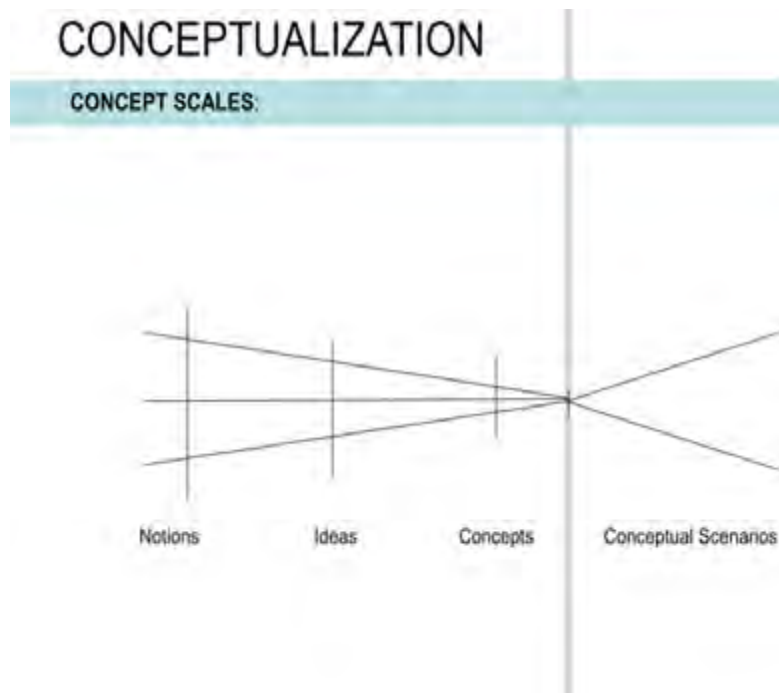
Kuloglu and Asasoglu’s pragmatic response that “creativity is conceiving and resolving problems from a different point of view, thus it can be taught and improved” (2010, p. 1674), might be an oversimplification of the issue, but Williams and Askland (2012) and Oxman (1999) have similar notions. Oxman (1999) proposes that the implicit aspect of design, such as creativity, should be absorbed into explicated design studio content. Oxman believes that “(i)t is difficult to develop an awareness of design thinking through conventional design activity, however if taught explicitly it is remarkably easy to understand” (1999, p. 112). Williams and Askland (2012) suggest the development of suitable tools for assessing creative

works. More importantly, they advocate that teachers and students explain their experiences with creativity to create an open dialogue about creative and conceptual aspects of design.

#### **2.4. Conceptual design concepts**

Design activities are made up of elements of design thinking and design making (Kuhn, 2001; Lawson, 2005; Schön, 1984b). Tuara and Nagai situate conceptual design in design thinking and define it as the “mental plan” which is devised in the “early phase of the design process” (2013, p. 9), before form-making commences. The conceptual design phase culminates in the design concept. Although boundaries have been created to illustrate conceptual design within the confines of this study, design is rarely a linear activity. It should be acknowledged that designers often return to adjust the concept as the problem becomes clearer to them (Dorst & Reymen, 2004; Lawson, 2005). Their thinking is also multi-layered, oscillating between thoughts on different design issues. Therefore the conceptual design phase should in reality not be seen as a “static invariant feature of the project”, but it does allow a designer the opportunity to “impose an order” on the messiness of the design situation (Heylighen & Neuckermans, 1999, p. 217).

Conceptual design is granular. Smaller nodes of thinking eventually crystallise into the design concept. Van Graan (2012) illustrates the progression in architectural design from broad design notions to design ideas to design concepts in Figure 2.1.



*Figure 2.1.* Concept scales in conceptualization (Van Graan, 2012)

Notions are the initial unrefined, untested thoughts that are inappropriate individually, but precursors to what the design solution might entail (for example, a coffee shop as a productive space). Ideas are more formal thoughts responding to a specific architectural issue (for instance, coffee shop seating arrangements that are suitable for working on laptops). Concepts are abstract constructs which provide a foundation or theme that can hold loose ideas together and form a basis for further design decisions (for example, a coffee shop as an office away from the office) (Van Graan, 2012). To draw up a concept, a designer first needs to be cognizant of design informants.

#### **2.4.1. Project brief**

The design brief contains client requirements. Experienced architects use these design informants as a departure point and expertly seek other non-expressed design informants. In architecture education studio project design problems are most often presented by means of a project brief. The project brief in the design studio is a “pedagogical tool” (Webster, 2008, p.

64). It simulates a client's design requirements as an open problem and provides students with the opportunity for situated learning. In the studio project the student and tutor role-play as designer and client, while the tutor takes on multiple roles, also as "experienced architect or consultant" (Mewburn, 2011, p. 364). The project brief is also a seminal reference document, as it includes project-related information such as context and constraints. Curated visual precedents are often also presented in the brief or in other project-based documentation and media.

Turkienicz and Westphal (2012) caution that the design object labels and visual precedents in the design brief could inhibit students' use of original forms. A design problem would label the type of building that students need to design, for instance a 'summer house'. Although Turkienicz and Westphal do not deny the value of images as a stimulus for the creative process, they warn that the visual representations that students find might direct them to follow a predetermined solution (for example, how most summer houses would look). They explain how this potentially impacts students' design process by reflecting that "The consequence of this procedure is the narrowing of the students' formal repertoire and, under a cognitive point of view, the limitation of their capacity to generalize and to make analogies about shapes and functions (p. 2)."

The studio design project brief also typically contains assessment requirements such as project outcomes, assessment weighting and classroom administrative information such as the project programme.

## 2.4.2. Design intent

The interpretation and prioritisation of design requirements and informants precede concept formulation (Perold, 2011). Perold illustrates the likely sequence of a designer's progression from project brief definition to concept in Figure 2.2.

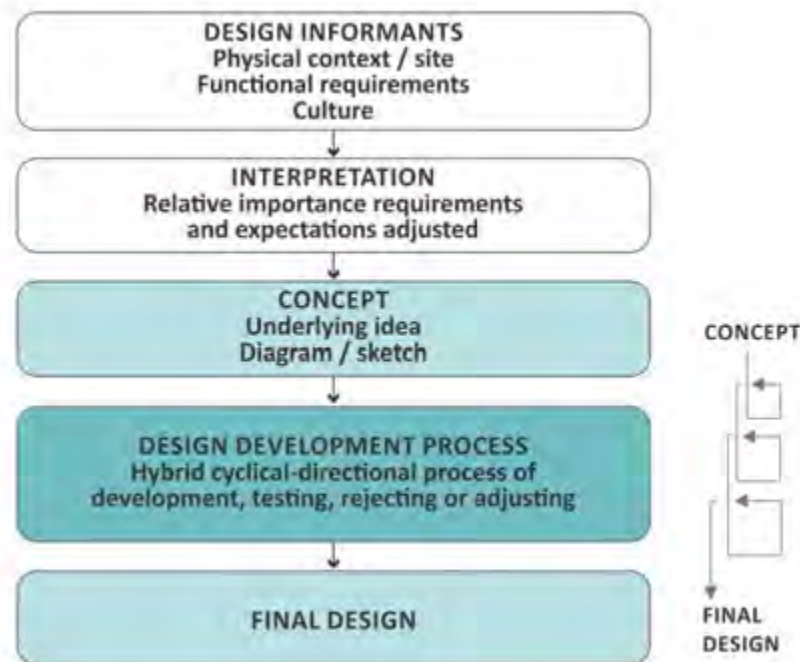


Figure 2.2. Design process model (Perold, 2011, p. 3)

A designer's response to a brief starts with integrating the various design issues. The interpretative phase, as positioned second from the top in Figure 2.2, is beyond the mere interpretation of separate informants, but also considers relational issues, especially when solving design requirement conflicts. Take, for instance, the classic architectural tension between function and form. An architect's desire to come up with an aesthetically pleasing design product will always be subjected to practicalities such as the site, elements and building requirements. This can also be seen as a designer's conflict between creative and scientific/technical solving of the design problem (Green & Bonollo, 2003).



The design intent (also referred to as the design rationale, design mission statement and/or design premise) converts the design requirements captured in the brief into a verbal or written articulation of the designer's "vision of a proposed solution" (Porter, 2004, p. 43). To enhance the clarity of a designer's "premise" (intent), Yatt (n.d, "Critical Thinking for Architects") proposes that it should be communicated verbally, rather than in sketch form. A design intent explicates the direction a designer plans to take, which will be further developed into a design concept and is not a mere summary of the brief or the fully realised design concept (Porter, 2004).

### **2.4.3. Design concept**

As mentioned earlier, a concept binds design ideas together under a single theme that provides a framework for the design process. Concepts emerge from a spectrum of triggers which range from the abstract – analogies, metaphors and similes – to the more pragmatic: concentrated issues or direct responses to aspects requiring solving (Muhammad, 2009). Tschumi is firm about the pivotal role of concept in architecture and says: "there is no architecture without a concept of an idea. Concept – not form, as one would suggest – is what distinguishes architecture from mere building" (as cited in Ots, 2011, pp. 23).

Van Graan (2012) suggests that architecture students experience various difficulties with the development of concepts, because they struggle in communicating the ideas to themselves and lack the graphic skills or vocabulary to communicate their ideas to others. He further suggests that students' latent conceptual design skills are potentially not developed, because concepts are unfamiliar and rarely discussed with them. The absence of necessary design heuristics in terms of students assessing the appropriateness of their concept or design precedent selections is also problematic.

## **2.5. Concept development support**

Expert design activity requires specialised knowledge and “designerly ways of knowing” (Cross, 2001, p. 49). Cross explains the multiplicity of design knowledge and knowing:

So design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world. Some of it is knowledge inherent in the activity of designing, gained through engaging in and reflecting on that activity. Some of it is knowledge inherent in the artifacts of the artificial world (e.g. in their forms and configurations – knowledge that is used in copying from, reusing of using various aspects of existing artifacts), gained through using and reflecting upon the use those artifacts. Some of it is knowledge inherent in the process of manufacturing the artifacts gained through making and reflecting upon the making of those artifacts. And some of these forms of knowledge can be gained through instruction in them. (p. 55)

Based on Cross’ notion of “designerly ways of knowing” (2001, p. 49), Heylighen and Neuckermans connect students’ development of “meaningful concepts” (1999, p. 212) in architecture to domain knowledge, heuristic design strategies and learning conversations with the tutor. These elements are architectural “things to know”, “ways of knowing” and “ways to find out”.

### **2.5.1. Architectural design knowledge**

The oldest existing codified architectural knowledge is captured in Marcus Vitruvius Pollio’s *De Architectura* written in the first century BC (Bech-Danielsen, 2013). According to Vitruvius three architectural guidelines must be adhered to:

These (public buildings) must be built in such a way as to take account of strength, utility, and beauty. The demands of strength will be met when the foundations are sunk to bedrock, and the building, materials, whatever they are, are carefully chosen without trying to save money; those of utility when the layout of the sites is faultless and does not make their use difficult, and when their arrangement is convenient and in each case suited to its particular situation; and those of beauty when the work has an elegant and pleasing appearance and the relative proportions of the individual parts have been calculated with true symmetry (as cited in Krufft, 1994, p. 24-25).

The ‘Firmitas’, ‘Utilitas’ and ‘Venustas’ triad was first translated from Latin by Wotton (1624), who named them ‘Firmness’, ‘Commodity’ and ‘Delight’. This Vitruvian triad is illustrated in Figure 2.3.



*Figure 2.3.* The Vitruvian guiding principles of architecture

‘Firmness’ refers to aspects of making the structure stand, such as materials, structure, durability, construction, sustainability and technology. ‘Commodity’ homes aspects of the “use of a building” (Krufft, 1994, p. 24), for example function, ergonomics, spatiality and activity. ‘Delight’ refers to aesthetics, appearance, beauty and the ability to affect an observer emotionally (Bech-Danielsen, 2013; Fein, 2009; Krufft, 1994). Gowans wonders why, despite a growing interest in aesthetics, across various translations Delight is always placed last in

the sequence “implying that (F)irmitas and (U)tilitas are to be regarded as essential, logical prerequisites of architectural beauty” (2015, p. 1). Fein feels that Delight should result from the resolution of the two more logical corners: “This is the ultimate ethical responsibility of the architect . . . : to produce Venustas by resolving the aspects of Firmitas and Utilitas” (2009, p. 42).

Due to scientific innovation, architecture domain knowledge categories have expanded and become more sophisticated. Architects now have to consider a wider array of issues, such as “acoustics, chromatics, cost control, ecology, ergonomics, material science, soil and other mechanics, project management, branches of physics, psychology and sociology”, which according to Heylighen and Neukermans (1999, p. 215) may or may not fit under the triad. Regardless, the Vitruvian triad is still a valid guiding force in modern-day architecture (Bech-Danielsen, 2013; Fein, 2009).

Bech-Danielsen (2013) talks of instances in modern architecture when the pillars of the Vitruvian triad have been dislocated, such as an over-focus on Firmness with the introduction of engineering in the 1800s, or the Commodity-obsessed “naïve functionalists” (Japha, 1987, p. 5), for whom form follows function (Bech-Danielsen, 2013). Fein laments that architectural guidelines have been “replaced by the intuitive search of forms” (2009, p. 43). Vitruvian’s followers agree that his intention was the balance between the three corners of the triad to enable a result that qualifies as architecture.

Heylighen and Neuckermans (1999) argue that a designer needs to be more than just knowledgeable about the separate aspects of Firmness, Commodity and Delight. For them an architectural designer should also be proficient in interrelating the Vitruvian triad:

(h)owever numerous, diverse and contradictory these issues (Firmness, Commodity and Delight) might be, it is the architect’s task to integrate them into a single design.

Imagine he designed a building by deciding on each aspect – lay-out, form, materials, construction, etc independently. The result may very well be functionally OK, keep upright and even look nice yet can hardly be called meaningful architecture if architecture at all. (Heylighen & Neuckermans, 1999, pp. 215-216)

Kunze likens the proposed unification of Firmness, Commodity and Delight under a single concept to a Borneo ring: “if you cut one off, the others fall off too, assigning the third ring the responsibility to keep the other two together” (n.d., p. 1). Architectural domain knowledge such as elements captured under the Virtuvian triad or even how to interrelate Firmness, Commodity and Delight can help a designer to develop a sufficient response to a design problem, but it does not enable a designer to create something new. To produce novelty in design, a designer needs fluency in certain designerly “ways of knowing” (Heylighen & Neuckermans, 1999, p. 216).

### **2.5.2. Design heuristics**

Expert designers rely on heuristics in the conceptual design phase to produce creative ideas (Yilmaz & Seifert, 2011). Heuristics are implicit methods developed through experience that help to accomplish tasks in expert ways (Collins et al., 1991) through a set of “rules, inferences and strategies” (Hart, 1996, p. 25). During the design process designers use multiple types of reasoning in constant cycles: deductive, inductive and abductive (Hahn, 2013; Pauwels & Bod, 2012). Induction and deduction are well-known logical reasoning processes. Deductive reasoning is derived by measuring a case against provided rules. Induction occurs over time when a pattern between various cases exposes the rules. Abductive reasoning makes forward leaps to design ideas and possible solutions, generating hypotheses that still need testing. Analogical reasoning has been identified as a fourth type of design reasoning. Analogical reasoning means the inference that can be made between two

cases, and contrasts logical thinking processes, but has elements comparable to abductive reasoning. Both derive less probable conclusions (educated guesses), and both are also frequently mentioned as sources of or foundations for design creativity (Hahn, 2013).

Huygens highlights three aspects of creativity: “1) combining ideas from different domains, 2) using visual imagination, 3) expanding and varying the search space of alternatives” (2001, p. 5). Comparing cases or precedents is a form of analogical reasoning and an important component in architecture projects and curriculum. This usually occurs in visual form. According to Perold when architecture students are presented with precedents, the proposed analysis method should be the “temporal opposite of the design process” (2011, p. 5). Normally a designer would interpret design informants to create a concept and design object. When analysing precedents a designer needs to interpret the design object to uncover what the underlying concept and design informants were (Huygens 2001, p. 3).

Casakin distinguishes between “surface” and “structural” (2004, p. 3) case comparisons. According to him, surface comparisons are obvious and superficial, easy to create, but difficult to successfully transfer to the design problem at hand. Structural comparisons are based on deeper, not easily observable properties that can be shared between the cases. Structural analogies are difficult to generate, but the adoption of a structural analogy to a design problem based on their deeper connection is likely to be more successful. Casakin also differentiates between “within-domain” and “between-domain” case comparisons. To illustrate the above by example: a “within-domain” comparison would entail likening precedents of existing apartment blocks before designing an apartment block (surface comparison), while a “between-domain” comparison might look at how animals or insects build cohabitation spaces (bird nests, beehives, etc.) and draw inspiration from that (structural comparison) (Casakin, 2004, p. 3).

To determine whether novice designers can be stimulated to higher-quality analogical reasoning, Casakin (2004) conducted a series of experiments with novice and expert designers. The control group was presented with complex design problems along with extensive visual stimulation and a clearly articulated expectation of the generation of analogies. The study found that both experts and novices benefitted from the explicated expectations and visuals. In terms of the quantity of analogies, both groups were able to generate more. However the novices indiscriminately produced analogies without applying the constraints and requirements of the design problem at hand. Based on his own findings, supported by the work of other researchers, Casakin (2004) concludes that expert designers are able to make deeper structural comparisons between cases whereas novice designers are limited to mostly making surface analogies.

Conceptual design knowledge and expert heuristic strategies are mostly implicit and ingrained in the tutor's experience (Heylighen & Neuckermans, 1999). In the architecture design studio these are best explicated through design critique conversations (Cho, 2011).

### **2.5.3. Conceptual design critique**

The design critique (also known as a studio critique, design review or tutorial) is an important interaction in supporting design development in the studio (Blair, 2006; Sara & Parnell, 2004). Oh et al. describe the objective of critiquing as a formative assessment approach providing “students with effective feedback that optimally contributes to their learning” (2013:18). During the critique the critic is expected to provide clarification pertaining to the success or failure of students' designs. Students can agree or provide counter-arguments to tutor opinions (Murphy, Ivarsson & Lymer, 2012). Idealistically the critique is a two-way conversation steered by the tutor's comments and question prompts (Socratic dialogue).

Research supports this as a successful method to stimulate a student's reflection and sense-making and improve their design argument (Wu & Looi, 2012; Yanik & Hewett, 2000).

In a mixed-method study of 60 architecture students and five tutors in the architecture design studio at the University of Leuven, Heylighen and Neuckermans (1999) researched the influence of tutor-student conversations on conceptual design development. They found that the quality of dialogue (i.e. "more frequent and richer") between student and tutor positively correlates with the quality of generated design concepts and development of conceptual design knowledge (Heylighen & Neuckermans, 1999, p. 233). Similarly, Al-Sayed et al. (2010) found that making architecture design reasoning and design processes explicit improves the design quality.

The goal of the first design critique should be for the critic or tutor to firstly assess the 'strength or weakness' of a student's premise (intent), then to assess the 'appropriateness of a student's concept' in relation to his design intent. As the design process progresses, the critic will in later critique sessions focus on stimulating reflection and providing feedback and assessing whether the student's design is a successful embodiment of the student's concept (Yatt, n.d.). In many instances, however, the design critique is pedagogically flawed. Contributing factors here include academic and emotional stress, time constraints and diminished student agency (Sara & Parnell, 2004). Yatt emphasises that in terms of concept development, empowered, questioning students gain more from the design critique and other project support tools:

... student's realization that he or she needs to question the meaning of any and all raw information with which they are presented, and successfully probe and analyze that information in order to formulate a Premise and Concept. If this realization is there, the Premise and Concept will be developed properly, and will serve as strong



foundations for all design development to follow. (n.d., “Critical Thinking for Architects”)

Williams is most concerned with the lack of clarity in tutor-student conversations in terms of what he refers to as “threshold concepts” these concepts “define ways of thinking that are distinctive to the discipline; in the field of architecture this might include thinking at a strategic level say, or using conceptual approaches to reconcile multiple criteria” (2014, p. 63).

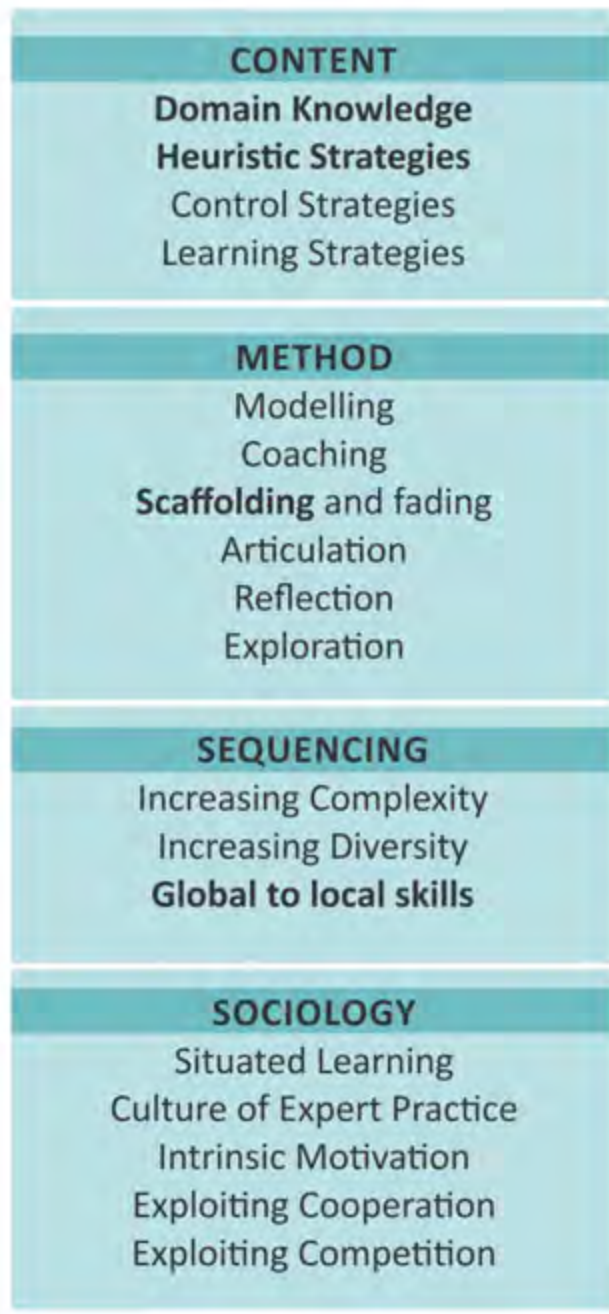
Williams suggests that tutors are often unaware of student struggles with these heuristic-laden concepts, because as experts these concepts have become embedded in their practice. He proposes that ‘threshold’ concepts need to be explicated. For this to happen, he advises that the tutor focuses more on the role of scaffolding than coaching. This notion is similar to Oxman’s (1999) suggestion of an explicit cognitive framework to support the learning of complex conceptual design knowledge, and Turkienicz and Westphal’s “Cognitive Studio” (2012).

## **2.6. Theoretical framework: Cognitive apprenticeship**

This study draws from Collins, Brown and Newman’s (1989) notion of cognitive apprenticeship (CA), proposed as a pedagogic strategy to make thinking processes visible to novices so they acquire expert “conceptual and problem-solving knowledge” (Collins et al., 1991, p. 2). For traditional apprenticeship to advance to CA, abstract tasks need 1) authentic contextualisation, 2) visible processes, and 3) diverse application and identification of subsequent patterns to enable skills transfer (Collins et al., 1991). For expert process models and novice process flaws to be observable “(t)he teacher's thinking must be made visible to the students and the student's thinking must be made visible to the teacher” (Collins et al., 1991, p. 3).

In educational research CA has been used to frame teacher education (Yeotis et al, 2003) and instruction of software and computer engineering (Bareiss & Radley, 2010). Art and design studio related studies using CA include those by Adullah (2011) and Conanan and Pinkard (2000). In the context of architecture education, studies located were limited to those by Morkel et al. (2013), Hokanson (2012) and Törnqvist (n.d.). Hokanson (2012) deems CA to be the most appropriate mainstream educational theory to elucidate design studio pedagogy.

Figure 2.4 shows what an encompassing pedagogical framework CA is. In CA a learning environment is made up of four main dimensions, namely content (“types of knowledge required for expertise”) methods (the “teaching and strategies employed to develop expertise”), sequence (“structuring tasks for learning”) and sociology (“the social conditions of learning”) (Collins et al,1991, pp. 6-9).



*Figure 2.4.* Characteristics of ideal learning environments (Collins et al., 1989, p. 476)

Although the separate parts of CA are interrelated, the brevity of this study necessitates the foregrounding of selected concepts that align with the most prominent issues in this study. The focus will be limited to two content categories (domain knowledge and heuristic strategies), a sequencing concern of global to local skills, and scaffolding as instructional method.

### **2.6.1. Domain knowledge**

In CA domain knowledge accounts for all subject material, articulated into tangible educational resources such as textbooks, guides, videos and web pages. Domain knowledge can include facts, information and explicated methods or procedures (Collins et al., 1991). Although this type of content has value, when used in isolation it is limited to being applied for lower-order thinking strategies (Bloom et al, 1956). This is because domain knowledge “provides insufficient clues for many students about how to solve problems and accomplish tasks in a domain” (Collins et al., 1991, p. 13).

In CA-related research studies, domain knowledge receives virtually no coverage. This is probably because CA was designed to move educational practices beyond the conveyance of decontextualised, factual information which is already in abundance in traditionally instructivist environments (Collins et al., 1991). In the context of the architecture domain, this kind of knowledge is what Cross (2001, p. 49), Heylighen and Neuckermans (1999) refer to “things to know”. In the context of this design studio project, domain knowledge was mostly conveyed to students by means of the project brief and Cognician cogs.

### **2.6.2. Heuristic strategies**

Experts acquire the ‘tricks’ of their trade through years of practice. These are referred to as heuristic strategies in CA. As mentioned in section 2.5.2 heuristics strategies develop with experience. Depending on the task and context, the expertise in execution could imply faster or more novel ways of doing. Although heuristic strategies depend on domain knowledge to some extent, Rolf (as cited in Tornqvist, n.d.) suggests that if a complex task is approached based on domain knowledge only, it will probably yield a “weak” result. Heuristic strategies explicated to novices provide them with an “intermediary” process between theoretical knowledge and tacit expertise acquisition through traditional apprenticeship practices (pp. 2-

4). In the context of the architectural design domain heuristic strategies, termed “designerly ways of knowing” (Cross, 2001, p. 49) are closely related aspects of creativity.

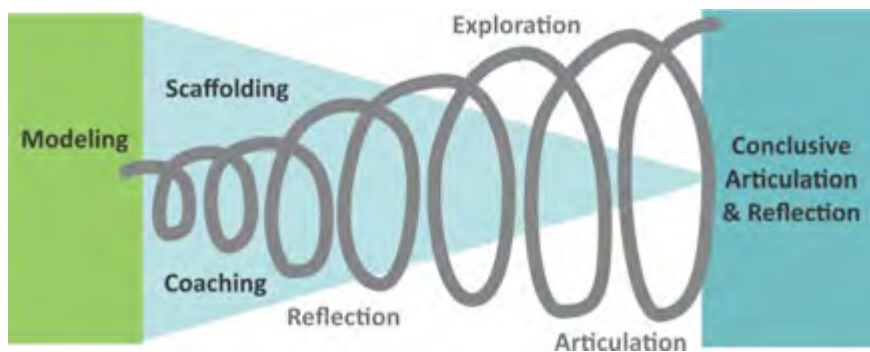
### **2.6.3. Global to local skills**

Global to local skills is a subsidiary under CA’s sequencing domain (see Figure 2.4). Through providing structure to tasks an expert can help a novice complete a task and preserve “meaningfulness” in the context of their activity (Collins et al., 1991, pp. 15) As illustrated in Figure 2.4 priorities for sequencing in CA is students’ exposure to a diversity of tasks, escalating complexity and “global to local skills”(Idem). Global skills should be prioritised over detail so that students build a “conceptual map” at the onset of a complex problem - this not only supports them in the portion of the problem that they are tackling, but also allow them to start mapping out their own process and accompanying heuristic strategies (Collins et al., 1991). Sequencing global skills before local skills is achieved through effective scaffolding.

### **2.6.4. Scaffolding**

Scaffolding is one of six pedagogical methods employed in the CA framework. CA is process-focused (Tornqvist, n.d.) and the methods provide an outline for teacher and student responsibilities to create ideal process conditions to facilitate expertise development in complex tasks. The CA methods can be applied as an instructional model, illustrated in Figure 2.5. In the practice of this model the contribution of the teacher (indicated as the first 3 actions in black text) is to 1) model and explain, 2) coach, and 3) provide scaffolding. Modelling entails an expert demonstration of how to accomplish a complex task. Explaining to students the reasoning behind approaching the task in a certain manner makes expert heuristic strategies visible to them (Collins et al., 1989). Coaching requires the close observation of the student and provision of guidance (in the form of suggestions or help) as

required. Coaching includes a blend of instructional strategies such as mentoring, modelling, scaffolding and feedback.



*Figure 2.5.* Cognitive Apprenticeship as instructional model Orey (2014, “Cognitive Apprenticeship”)

The exploration, reflection and articulation methods fall more within the student domain (indicated in grey on Figure 2.5). Exploration refers to students transferring skills modeled to explore a problem space or new challenge further through independent problem finding.

Through embedding opportunities for students to reflect (by comparing their process with that of an expert) and articulate (verbalising their thinking), students increase their control of their problem-solving abilities. As students become more able (depicted by the expanding spiral in Figure 2.5), support should gradually be faded (the decreasing light blue bar). Fading as a gradual decrease of support to allow students to grow their independence is another (less known) strategy in CA.

Bar a handful of authors (Hokanson, 2012; Morkel et al., 2013; Törnqvist, 2011), the three instructional CA terms ‘modeling’, ‘coaching’ and ‘scaffolding’ are rarely observed in design studio literature. However, their essence is captured in design studio critique and tutelage. As with their application in other contexts, modeling, coaching and scaffolding flow from one another. A single interaction with a student can comprise elements of all three methods.

Collins et al. highlight the value of the combination as “(t)he interplay between observation, scaffolding and increasing independent practice, that aids apprentices both in developing self-monitoring, - and correction skills and integrating the skills and conceptual knowledge needed to advance to expertise” (1989, p. 456).

Collins et al. (1991) incorporated scaffolding (Bruner, 1978; Rogoff, 1990; Vygotsky, 1978) into the CA framework as a foundational aspect. Collins et al. (1991, p. 14) defined scaffolding as “the supports” a teacher avails to a student to perform a task, and considered this as the foundation of CA. It is a process-accompanying strategy suited to *in situ* complex problem solving. The aim of scaffolding is twofold: firstly to support student success during a specific process, and secondly as a means for students to learn that process (Guzdial & Kehoe, 1998, p. 290).

Scaffolding is closely aligned with Vygotsky’s notion of the zone of proximal development (ZPD) (Dennen & Burner, 2008). Vygotsky described the ZPD as “the distance between the actual development level as determined by independent problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky & Cole, 1978, p. 86) and what can be accomplished without help.

De Grassi et al. (2008) promulgate scaffolding of design students’ process as a prerequisite to establishing best design practices, but Dorst and Reymen caution that scaffolding might negatively affect designers with more expertise: “Instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners. This phenomenon is called the expertise reversal effect” (2004, p. 8).

Scaffolding originally implied the help which more knowledgeable others provide, but has since expanded to include conversations with not necessarily more knowledgeable others

such as peers, and physical scaffolds such as resources, artifacts and technology tools (Puntambekar & Hübscher, 2005).

## **2.7. Technology tools in the design studio**

Although use of technology tools in the design studio provides opportunities for expanding the ZPD, improving articulation, reasoning and decision-making; often these tools are used only for design representational purposes (Ataman, 1999). Brunner (2007) found that students have the same perceptions, limiting the value of design technology tools to sketching and modelling applications like AutoCAD (Brunner, 2007). Wang (2011) proves that if applied effectively, even just leveraging these representational affordances has benefits. Her research concluded that first-year design students who used computer-assisted design (CAD) as part of their conceptual design process fared better than their counterparts who relied on manual media.

Brunner (2007) exposes design thinking development tools as being product-focused and not supportive of design thinking processes. Likewise, Fiedler (2003, p. 9) points out that “person-in-process” tools are scarce and much needed in educational contexts. To support the design process, Brunner (2007) incorporated a reflective blog activity as part of her interior design students’ conceptual processes. Her qualitative research findings were that students did not find the blogging useful. In interviews students explained that the tool lacked situated-ness in relation to their design processes. Process blog posts were created after the process concluded and the blogs themselves became another design product rather than a process tool. Percy (2004), however, questions whether these types of online conversations can drive deep architectural learning discussions.

Brunner had more success with an earlier study in 2004 (as cited in Brunner, 2007) where the use of a schema-based learning tool improved students’ design solutions in terms of



organisation and decision making. Arjun and Plume (2011) researched the impact of a design conversation system ‘Design Thinker’ on architects’ design conceptualisation, and found that the system was more useful to less experienced designers. They concluded that it “could be a useful pedagogic tool in the education of architectural design” (p. 52).

## **2.8. Scaffolding tools**

In the context of this study, Cognician could be classified as an intelligent tutoring system (Anderson et al, 1985), conversational tool (Fiedler, 2003) or cognitive tool (Jonassen, 2007). The decision to refer to the system as a scaffolding tool (Reiser, 2004) in this study is based on its application as part of the blended studio project, where it was used to supplement tutor scaffolding and support the quality of conversations between learners and tutors. The use of software scaffolding tools offers two opposing features to assist a student in a complex learning task: it can add “structure” (Reiser, 2004, pp. 283) or “problematize the subject matter” (pp. 287). Task structuring involves “chunking, sequencing, detailing or any other means to structure a task so as to fit in a learner’s ZPD (Sugar & Bonk as cited in Morkel et al.,2013, pp. 8). Reiser refers to Lepper’s (as cited in Reiser, 2004, pp. 287) research that found that expert tutors aim to keep their tutees at an optimum level of active problem-finding (problematization). This enable students to keep expanding the boundaries of the their ZPDs.

Liu (2000) says that we still have much to learn about the relationship between decomposing complexity and solution synthesis in design creativity (pp.275).

Dennen and Brunner (2008) point out that unlike human tutors scaffolding tools are not yet able to adjust to learners individual ZPD needs. They refer to Bell and Davis’s (2000) findings from a study on the implementation of a science scaffolding software system called

Mildred. Students benefited more from Mildred's general scaffolding prompts than from the too specific prompts. Bell and Davis discovered:

Generic prompts allow – in fact, force – students to reflect in their own ‘default ways’  
These defaults may be, for many students, more useful than our best intentioned direction; most students appear capable of productively taking charge of their own reflection...students responding to generic prompts developed a more coherent, integrated understanding...(pp.147).

Reiser is concerned with how scaffolding tools fit into the existing learning context. He says “expectations and practices in the classroom” (2004, p. 298) determine the success of scaffolding tools for student learning. He identifies two critical factors to consider when implementing a scaffolding tool in a blended context. Firstly, he says all students need equal access to the resources relevant to their task. This includes information, technology, appropriate internet access and so on. Secondly, he highlights that the specific “ways of thinking” that the tool is employed to support must be the same as what exists throughout the entire “classroom system” (Reiser, 2004, p. 299). The scaffolding tool must therefore mimic the same ways of conceptual thinking that the design studio tutors, brief and other project scaffolds propagate.

## **2.9. Cognician Cogs**

Cognician Cogs were introduced at the beginning of this study as a software platform that simulates a dialogue. This section aims to reveal a number of the platform's pedagogical offerings relevant to this research project. Based on the Socratic Method of prompting and modeling questions, the tool harnesses the age old way of apprenticeship where learning happens through conversation. Yengin and Feller (2012) say this kind of approach is conducive to deep learning and improved learner motivation. The conversational guides

(Cogs) employ the questioning strategy to structure and guide thinking. This offers benefits for the design studio. Yanik and Hewett (2000) found that practicing rigorous “dialectical questioning” improves students’ design argument. Wu & Looi concur and promote question prompts as an effective method to stimulate reflection and construct understanding (2012).

Through interacting with a Cog, a student is forced to articulate their thoughts by typing them into the response field. This function holds promise for making architecture design reasoning and design processes explicit, which according to Al-Sayed et al (Al-Sayed et al., 2010) improves design quality. The Cogs also combine dialogue with just-in-time multimedia content. Providing students with just-in-time content during complex tasks help them “effectively control cognitive load” (Kester, Kirschner, Van Merriënboer & Bäumler as cited in Morkel & Voulgarelis, 2010, pp, 3). The Cogs’ interface has been designed for the user. It is simple and does not impose a complex “process at a cognitive level” that will hinder the design process (Davies, 1995, pp.115). The tool has the aesthetic affordance (Bower, 2008) that it resembles social networking platforms that students are familiar with. In the same manner as a chat on a social networking platform, the expert in this case is represented by an avatar. Chen et al (2012) have noted the positive impact on students’ motivation to read and engage with a tool when they are conversing with an empathetic avatar. Finally from a tutor and institutional standpoint the most valuable feature of Cognician is that the conversations with the expert are not in real-time, but pre-scripted.

## **Chapter 3 Methodology**

### **3.1.Introduction**

In this chapter I account for the methodology used for this study, which examines the use of Cogs during a second-year architecture studio design project. I justify the critical realist perspective, case study approach and use of mixed methods to investigate the phenomenon. I describe the research site and curriculum design project in which the Cogs were used. The study participants (tutors and students) and method used to select a sample student group is introduced. I present the data collection process, instruments, my retroductive data analysis procedure and supporting tools (technological and analytical), and finally address issues concerning ethics and validity.

### **3.2.Research paradigm, approach and method**

A research paradigm provides the “intent, motivation and expectations” (Mackenzie & Knipe, 2006, p. 2) for a study and establishes a foundation for research design decisions. In this study I adopt a critical-realist perspective (Bhaskar, 1998) for a single case where students used Cogician Cogs to support their development of a pop-up shop concept.

Critical realism is a complex meta-theory pioneered by Roy Bhaskar (1975). The paradigm requires that ontology (what reality is) and epistemology (what we know about this reality) be treated separately. Danermark et al. (2002, pp. 5-6) explain that “there exists both an external world independently of human consciousness, and at the same time a dimension which includes our socially determined knowledge about reality”. From a critical realist perspective “the world is structured, differentiated, stratified and changing” (Danermark et al., 2002, p. 5). A key tenet of critical realism is that the world is “stratified” into the “empirical” (what can be readily observed), the “actual” (what actually happens, whether it can be observed or not) and the “real” (the underlying causes for what actually happens). Critical realism’s

sensitivity to causality makes it useful when investigating underlying reasons as to why certain events transpire (Smith, 2006; Easton, 2009).

This study meets at the confluence of design, ICTs in education and blended learning environments. Precedents and reasoning for the application of critical realism were drawn from consulting critical realist-positioned studies in design, information systems (IS), blended learning and educational technology.

Until recently design research was mostly situated in objectivist, constructivist and subjectivist epistemologies (Feast & Melles, 2010). Russo and Feast (2013) argue that these perspectives are too limiting to interpret the complexities of design knowledge and propose critical realism as a more suitable alternative. Likewise, Carlsson (2003), whose research is in the IS arena, also advocates critical realism as a new alternative. He joins other critics in pointing out weaknesses in positivist, naïve realist, interpretivist and other modernist approaches used in researching ICTs. Weaknesses identified include “theory-practice inconsistencies” (Smith, 2006, p. 192), an overemphasis on “micro phenomena” (Layder, as cited in Carlsson, 2003) and neglecting “structural” and “systemic” issues (Carlsson, 2003, p. 2).

Unlike IS research, investigations into the use of ICTs in education have received very little critical realist treatment (Pratt, 2013). Pratt (2013) cites the critical realist contributions of only two researchers, namely Gutteridge (2006) (blended course delivery) and Reddy (2014) (provision of digital language learning resources). A couple of years earlier Brown (as cited in Withell & Haigh, 2014) proclaimed a shift away from empiricist and idealist paradigms in the study of teaching and learning contexts. From Brown’s work Withell and Haigh deduced that from a critical realist perspective “learning environments are seen as episodic and complex assemblages of causal mechanisms and contextual factors that activate or constrain

learning” (Withell & Haigh, 2014, p. 3). They suggest that the success in achieving set outcomes when using learning tools depends not only on factors inherent to the student, but also those relating to the context, teacher, curriculum, faculty and institution. Reddy’s (2014) sentiment in this regard is that critical realism provides a researcher with a holistic understanding (social and pragmatic) which can be valuable for quality improvement.

### **3.2.1. Case study using mixed methods**

This study endeavoured to explore an authentic account of piloting a scaffolding tool in the selected context. Case studies such as this one provide the opportunity for in-depth explanations of a single event. The case study approach as recommended by critical realists such as Sayer (2008) and Easton (2010) underpins this study. Easton defines case research as an investigation into “one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process” (Easton, 2010, p. 119). Sayer (2008) suggests that case studies afford the researcher the opportunity to unravel how the parts of a case or event are connected.

Creswell (2015) defines mixed methods as an investigation in which both quantitative (“statistical trends”) and qualitative data (“personal stories”) are gathered and integrated. Mixed-method research is another way to obtain a broader understanding of events (Zachariadis et al 2010). Smith concurs and suggests that “a more complete picture of the implementation of technology in context” requires insight into technology and how humans “socially construct technology” (2006, p. 207). Tashakkori and Teddlie (1998) likewise suggest that mixed methods capture the richness, complexity, and interdependence of events, actions, and conditions in the real classroom.

To understand the research problem interpretations are drawn based on the combined strengths of both qualitative and quantitative data sets. Johnson and Onwuegbuzie (2004)

support Creswell's notion that qualitative and quantitative research in tandem create data synergy. Maxwell and Mittapalli (2010) explain this synergy from a critical realist methodology as a reasoning "dialogue" between the two data streams.

This study was concerned with learning, an internal process, and therefore the quantitative data played a supportive role and are embedded in the larger qualitative research design. Following Creswell (2015), this study can therefore be described as a concurrent embedded design of a mixed-methods study, and noted as "QUAL(quant)".

### **3.3.Site, Cogs in the curriculum and participants**

My own work context at the time of this study did not offer a suitable opportunity to explore the use of ICTs in education as required by the Master's programme at UCT. I therefore drew on my personal networks to locate a suitable site for my study.

A mutual friend introduced me to Tutor A and we discovered that we share an interest in design and the use of technology in education. Tutor A is a senior lecturer in Architectural Technology at a university in South Africa. As mentioned at the outset, Tutor A was already considering using the specific tool (Cognician) as part of a class design project when I met her, and my proposed study provided an opportunity for research. Tutor A selected her second-year class in the NDip in Architectural Technology for this project. Tutor A (personal communication, July 19, 2013) cited the group's previous design exposure, base-level architecture design knowledge and fair level of technology readiness as reasons for the decision.

This second-year course in Architectural Technology comprises four compulsory subjects: Practice 2, Studio work 2, Construction and Detailing 2 and Practical Studies 2. The academic programme is delivered via a blended model with week blocks (Monday to Friday)

on campus, combined with email and social media interaction with peers and tutors and lecturers throughout the year.

The assignment for the selected studio project was to design a pop-up shop for Wupperthal, a small rural community in the Cederberg Mountains in the Western Cape Province of South Africa. For authenticity the project was modelled on a real need expressed by the community to help the village capitalise on the growing tourism industry.

Over the five weekdays of the on-campus block, the project moved through the following phases: (1) brief definition and design exploration; (2) concept design formulation; (3) sketch design formulation/design of technology; (4) technological resolution and detailing, first as a sketch and then as a three-dimensional model. Tutors conducted a number of pin-up and one-on-one design critiques to support students' design processes.

Five Cogs were employed on the first day during the brief definition and design exploration stage. The Cogs were designed to help students think through the procedural aspects of the design brief in preparation for the first one-on-one design critique. The Cog themes which Tutor A selected to support the project were: Function, Activity, Ergonomics, Materials and Construction. Students completed the five Cogs on the first day, preparing for their critique the next day. A sixth reflective Cog was completed after students' first design critique. Apart from using the Cogs, this process is similar to those of most other projects in the specific course. Figure 3.1 illustrates the process followed in this studio project.



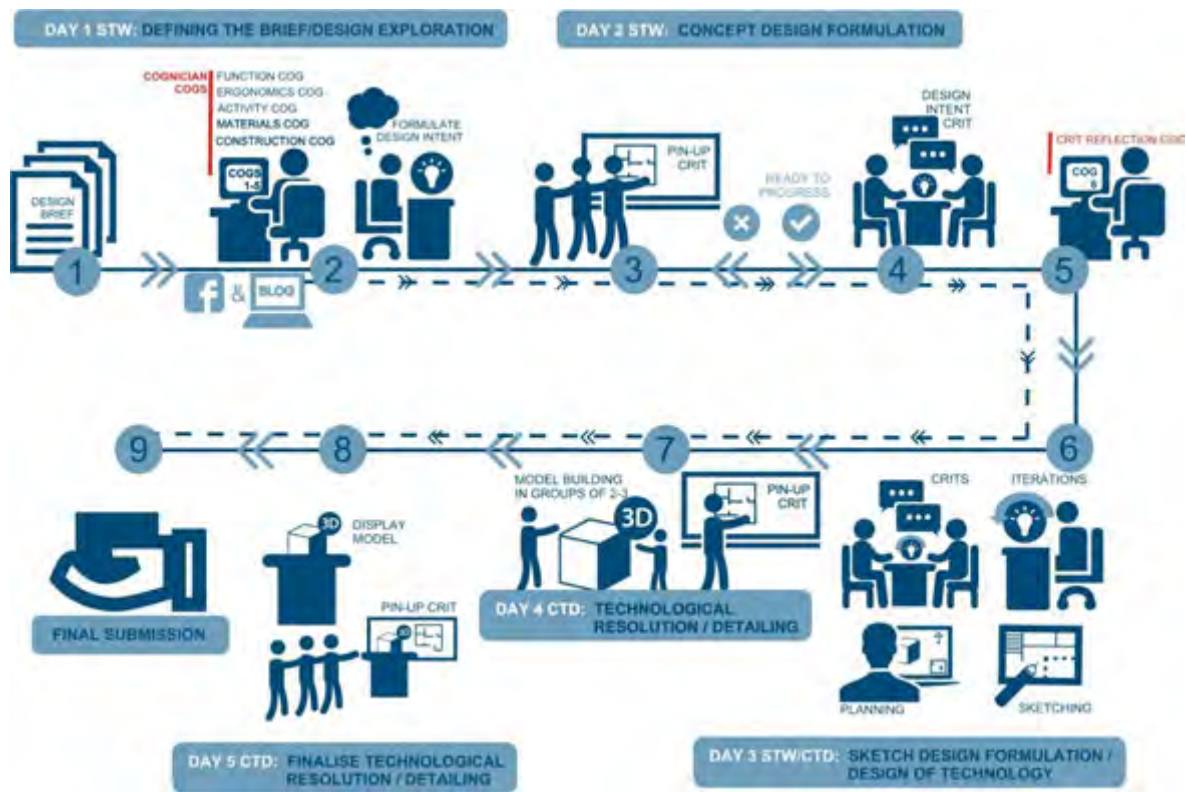


Figure 3.1. Studio Work project process

Step 1 in Figure 3.1 represents the written design brief that initiated the design project and process for the architecture students on the first day of block 3. This brief was handed to students in hard copy, but also presented on an overhead projector by Tutor A when she introduced the project.

Step 2 was still part of day 1, but included students' work after class hours. This step portrays students' preparation for the design critique. Students were asked to complete the first five Cogs and formulate a design intent to present at the design critique the following day. The landing page for the Cogs and the Function Cog can be seen in the screenshots in Figures 3.2 and 3.3. (The platform interface has since been upgraded.) A full script of a Cog conversation has been included in Appendix D.



Figure 3.2. Screenshot of Wuppertal Cogs landing page

(The university's institutional branding has been deliberately blocked out.)

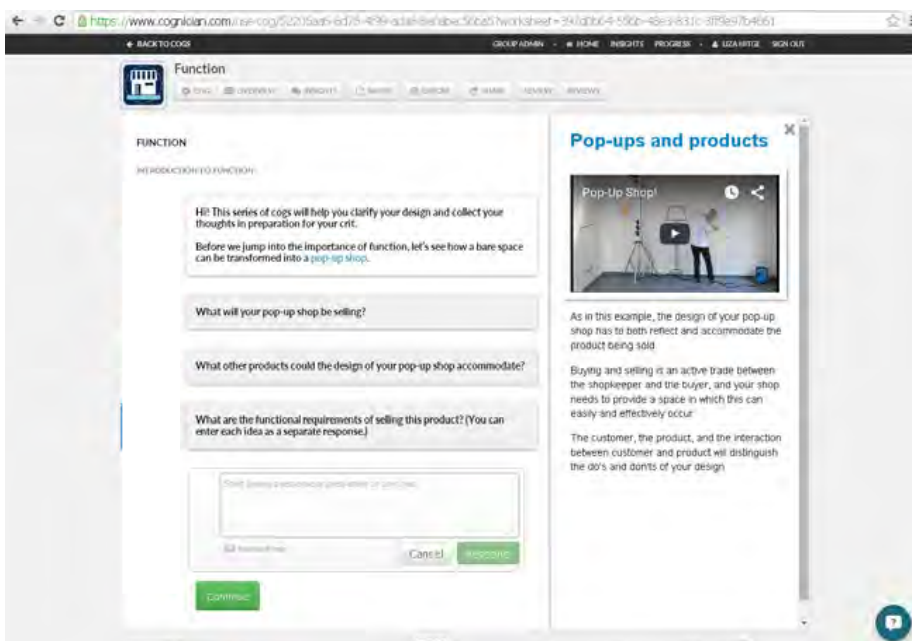


Figure 3.3. Screenshot of Wuppertal Cognician Function Cog

(Tutor A's avatar, left of the question prompts, has been deliberately blocked out.)

On day 2 the process reached the concept design formulation phase. During Step 3 (Figure 3.1) students presented their work in a quick public pin-up critique. Students whose designs had progressed well enough could advance to the individual design critique. Students whose designs were not yet up to standard were advised to conduct another round of improvements based on feedback in the pin-up critique.

The design critique conversation between student and tutor is shown in Step 4, and once completed students reflected on the critique by working through the final, sixth Cog (Step 5).

Steps 1 – 5 focused exclusively on the Studio Work section of the project. In Step 6 students progressed to sketching and planning a three-dimensional version of their design.

After another round of pin-up critiques, students built three-dimensional models in groups of two or three (Step 7). These models were then displayed and critiqued (Step 8) and submitted for summative assessment (Step 9).

Throughout the process students kept a design process blog. Their reflective postings contributed to their Studio Work mark for the project. The class Facebook group was also used by Tutor A for announcements and to facilitate interaction with students and between peers. The scope of this research project was limited to the initial conceptual design phase of the design project, Steps 1 to 5.

### **3.3.1. Participant selection process**

#### **3.3.1.1. Students**

Forty-three students at varying levels of scholastic ability and design-related skills registered for this course. Only 41 of those were present for the project and 39 completed the course. Data from the 41 and 39 students were included in the quantitative survey data and quantitative students' marks respectively.

I used convenience sampling (Teddlie & Yu, 2007) to select a sample group of nine students for collecting qualitative data. Students waiting to proceed to their design critique provided the captive group. To ensure a representative sample I also included elements of stratified sampling (Cohen, Manion & Morrison, 2007). I categorised the class before the project commenced by creating sub-groups with shared characteristics within a larger population. The general strata used were gender and academic performance. For this project it was important also to ensure a diverse sample in terms of technological savviness and technology affinity. As this information was not available beforehand, I based this variable on the observed frequency of student engagement on the class Facebook page in the weeks prior to the block week as a proxy for “technology affinity”.

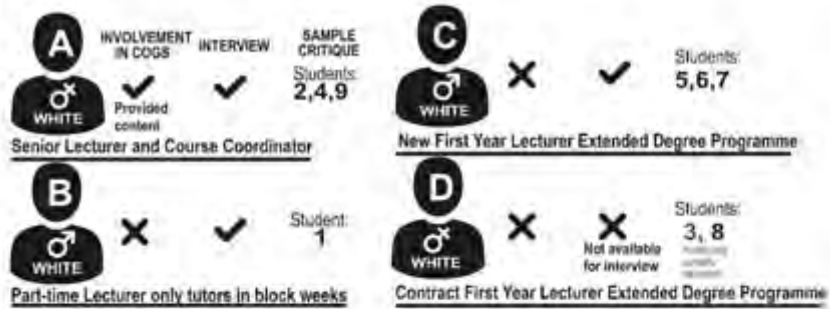
The final convenience-based selection occurred just after the pin-up critique (see Step 3, Figure 3.1). Tutor A would signal to me that a student was ready to proceed to his/her individual design critique, allowing me the opportunity to consider their profile and approach them to be part of the study.

This is not an infallible sampling strategy as it has potential weaknesses due to the immediacy of the decision-making, and factors other than technology and social media affinity might impact upon students’ engagement in the class Facebook group. To verify choices made, questions about students’ technology use in their design process were posed as an introductory part of the interview. The data and demographic information about the sample group is captured in Figure 3.4.

# PARTICIPANTS

2ND YEAR  
ND: ARCHITECTURAL  
TECHNOLOGY  
STUDIO WORK BLOCK 3

## TUTORS (4)



## SAMPLE STUDENT GROUP (9)

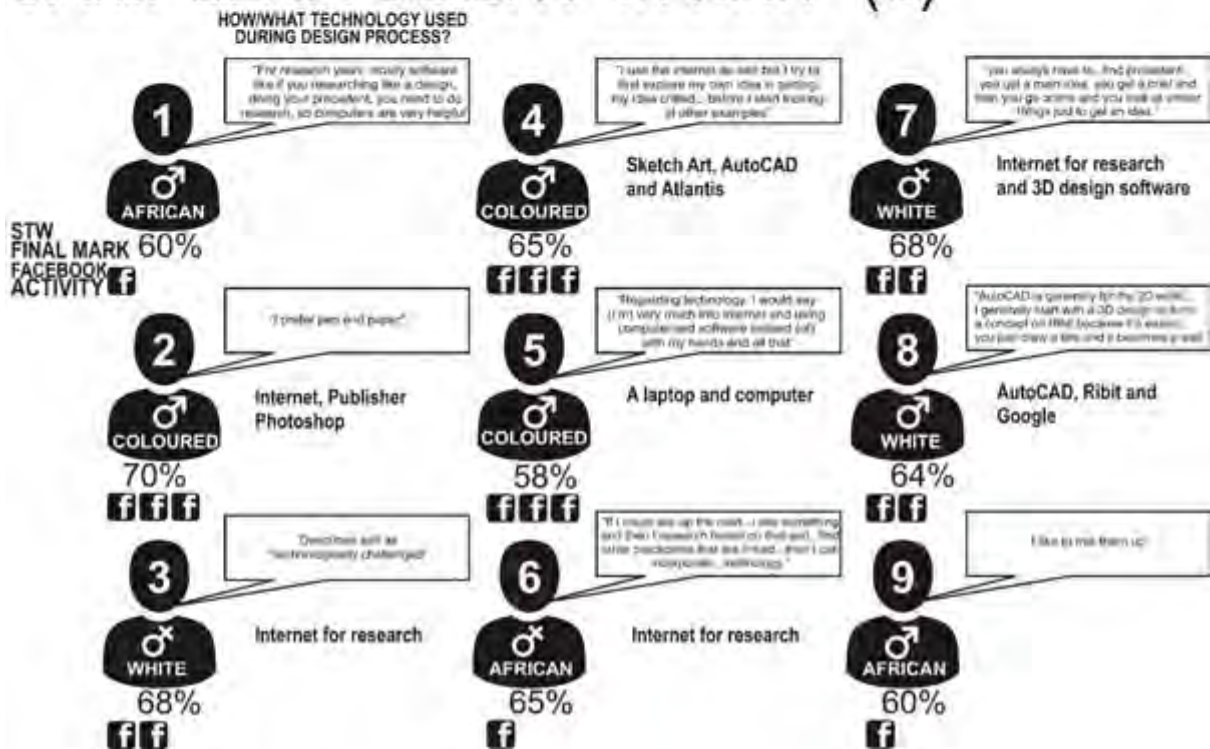


Figure 3.4: Research participants

Initially I decided upon a sample group of eight students. However, a recording device failure occurred and only a portion of Student 3's design critique was captured, so I included an additional student with similar characteristics.

### **3.3.1.2. Tutors**

The tutor sample for this study was compiled through a purposive sampling technique (Teddlie & Yu, 2007:80). As mentioned, in the architecture design studio setting lecturers are referred to as tutors. Due to budget constraints block weeks are run with a minimum number of staff members. Two staff members were involved in the design formulation and sketch phases that form the Studio work part of the design project. Tutor A had knowledge of the Cogs and provided content direction to the Cog writer at Cognician. Tutor B had very little knowledge about the Cognition system, except that it would be used as part of the project.

As it was important to dilute Tutor A's potential partiality, the tutor sample was intentionally enlarged. Tutor A invited two additional lecturers also to conduct design critiques (Tutors C and D).

Summative assessment of the Studio work project was conducted by Tutor A and a faculty member who was not involved in the block week or Cog development. Interviews were planned with Tutors A, B, C and D, but Tutor D was unable to be interviewed at the time. The design critiques which Tutor D conducted were however included in the study.

### **3.4.Data collection**

It was uncertain what would transpire when the Cogs were incorporated into the studio project. There were no precedents available or studies that were similar enough upon which to base this investigation. My strategy was to collect as many possible strands of quan and

QUAL data during the process to enable a thorough inquiry (Figure 3.5). This eventually included:

(1) a copy of the studio project design brief (on accompanying CD) (3.4.1);

(2) all content in Cogs 1 to 5 (on accompanying CD) (3.4.2);

(3) the recordings of the design critique conversation between the sample students and tutors (transcriptions on accompanying CD) (3.4.3);

(4) the responses to the survey questions in Cog 6 (on accompanying CD) (3.4.4);

(5) the Cog 6 scripts for the sample group (on accompanying CD) (3.4.5);

(6) recordings of the interviews I conducted with the 9 sample students and 3 tutors (interview questions Appendix A, interview transcriptions on accompanying CD) (3.4.6);

(7) my observational notes (on accompanying CD) (3.4.7); and

(8) the Studio work term and year marks I obtained in the months following the project (on accompanying CD) (3.4.8).

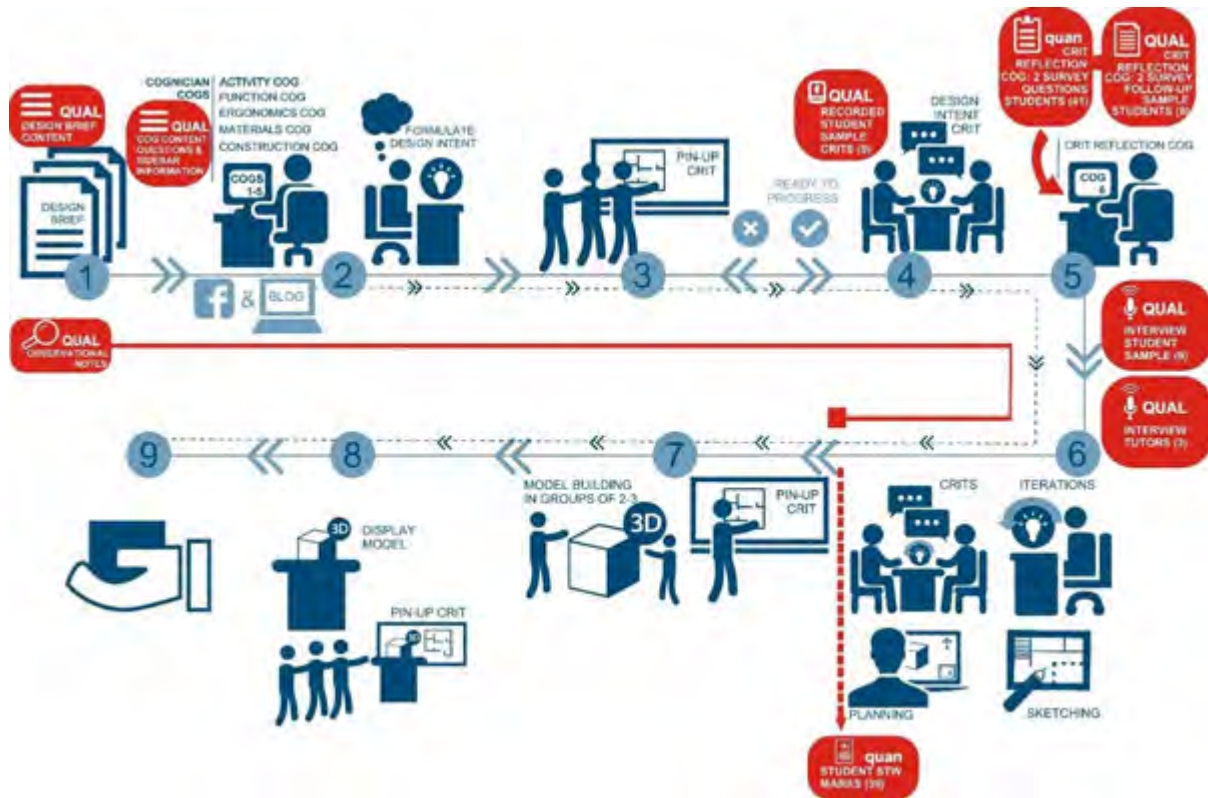


Figure 3.5. *Studio work project data collection points*

### 3.4.1. Project brief (QUAL)

The design studio project brief (on accompanying CD) was a seven-page text document that included five images. It contained the introduction to the project, an explanation of assessment and marks, the programme for the block week and an overview of the Wuppertal community and pop-up shop phenomenon. According to the brief, the pop-up shop would be used to sell local produce, crafts and goods. The brief also stipulated that the pop-up shop, when not operational, would need to be restricted to a size of 1.8m wide by 2.5m long by 1.8m high. In addition, the document contained guidelines for students to consider the functional and technological aspects of their pop-up shop designs. They were provided with question prompts in the brief to get them started. Contextual factors were indicated as less important for this project. The outcomes for the two different subjects, Studio Work 2 and Construction and Detailing 2 were stipulated in the brief. Finally the design brief also provided instructions on the project blog diary that students were expected to keep.



### **3.4.2. Cogs 1 to 5 content (QUAL)**

As mentioned already, Cogs 1 to 5 with themes Function, Ergonomics, Activity, Materials and Construction were completed on day 1 of block week 3 in preparation for the design critique the following day. The Cogs contained question prompts and side-bar content in text, image and video format. I obtained the scripts for the Cogs and content from Cognician in Word format, but also had access to all the Cogs on the platform for the full duration of this study (see accompanying CD for Cog scripts 1-5).

### **3.4.3. Design critique recordings (QUAL)**

The design intent critiques were conducted by Tutors A, B, C and D. This happened at four different tables spread around two adjacent Studio Work venues. Students worked on their projects in one of the two venues while the critiques were underway in the other. Students were allowed to gather around a critique session of any other student, if they chose to. I used mobile technology to record the critiques conducted with the nine sample students. Once a student whom I had identified for the sample group was ready to proceed to the critique, I approached him/her for permission to be part of the study. I was mindful not to intrude on the critique, so merely activated the recording function on the device, moved away and observed from a distance.

The length of the critiques varied from 5 to 20 minutes. Tutor D's critique sessions were significantly longer. Unfortunately a recording device failure resulted in only a portion of the critique conversation between Tutor D and Student 3 being captured. This led to the addition of another student (with a similar profile) to the sample group, as mentioned earlier. The audio files were sent to a service to be transcribed (accompanying CD).

#### **3.4.4. Survey questions (quan)**

A sixth reflective Cog was only made accessible after the design critique. The Cognician content writer added three closed questions of her own design to Cog 6 that yielded quantitative data. The questions posed were:

Q1: On a scale of 1 to 10 (with 1 being the lowest and 10 being the highest) how would you rate how well your crit went? *(To indicate their response students could select a numerical value from 1 to 10 on a slider.)*

Q2: And in what way/s did working through the Cogs before your crit play a role in how you felt about and prepared for it? *(Students could select from four response options namely: “No Role Whatsoever”, “Some Role”, “Huge Role” or “Other”.)*

Q3: To what extent would you say that you were affected by using Cogs in preparation for your crit, where at 1 there was no effect at all, and at 5 the Cogs had a significant influence on your preparation? *(Students could indicate their response on a numerical slider, selecting a number between 1 and 5.)*

Survey questions 2 and 3 were very similar and I therefore decided to omit question 3 from the study. The responses captured by the Cognician system was exported and supplied to me in an Excel file (accompanying CD).

#### **3.4.5. Sample student Cog 6 transcripts (QUAL)**

All three Cognician survey questions had a follow-up question asking students to provide reasons for their choices in the survey. Cog 6 transcripts for the sample student group were obtained from Cognician. This allowed me access to the nine students' responses to the follow-up questions for survey questions 1 and 2. Cog transcripts were provided to me in html files and I converted them into Word documents (accompanying CD).

#### **3.4.6. Interviews (QUAL)**

Interviews are a key method for collecting qualitative data as they “provide a deep, rather than a broad set of knowledge about a particular phenomenon” (Phillips, 2001, p. 6). For this study I conducted in-context, semi-structured interviews with the three tutors and nine sample students. See Appendix A for interview questions. Audio files were captured using mobile technology and transcribed (accompanying CD). Tutor D was not available to be interviewed at the time.

#### **3.4.7. Observational notes (QUAL)**

Sayer warns that “observability may make us more confident about what we think exists, but existence itself is not dependent on it” (Sayer as cited in Zachariadis et al., 2010, p. 5). Observational notes formed part of my larger mixed-method design. I captured my notes on a mobile device and processed them into a Word document for analysis (accompanying CD).

#### **3.4.8. Studio work marks (quan)**

I obtained the Studio Work term marks for this project along with marks for the other three terms. Marks were provided in Excel by Tutor A (accompanying CD).

### **3.5.Data analysis**

#### **3.5.1. Data processing**

All audio files were transcribed by a transcription service. Text-based files were converted into Word documents and lines numbered and then entered into Excel files. Appendix B provides full data processing details.

#### **3.5.2. Data analysis procedure**

Analysing the data in this study followed a retroductive reasoning process, as adopted by Russo and Feast (2013) in their analysis of complex design practice and Withell and Haigh

(2014) in their study of the development of design thinking expertise. Retroduction refers to a process of “going back from below or behind” (Lewis-Beck et al, 2003, p. 972) to understand the mechanisms behind observed patterns or irregularities.

The key steps for the analytical process of this study were loosely modelled on those Withell and Haigh (2014) employed for their design thinking development research, which broadly include:

1. Identifying tendencies in student learning outcomes and perceptions of learning outcomes after using the Cogs;
2. Reviewing relevant literature to help clarify and confirm mechanisms and contextual factors;
3. Formulating hypotheses;
4. Testing hypotheses; and
5. Identifying opportunities for the enhancement of the Cogs for architecture education (e.g. changes to Cogs, content, learning activities, teaching methods and so on).

After all the raw data were scrutinised I made initial connections between data sets in search of understanding what transpired when Cogs were used in the studio project. In her interview Tutor A suggested that after the summative assessment of the project (with an uninvolved lecturer) it seemed as if the lower-performing students achieved higher marks than usual in this project. I tested the legitimacy of this statement by dividing the class into three groups, those with lower, average and higher average year performance marks in Studio Work.

Next the quantitative evidence of student perceptions in relation to their performance in design critique was considered. To further clarify possible tendencies in this data unit I

compared sample student responses to the follow-up question where they were asked to explain their responses with those of the whole class, to test whether the sample group would be able to provide a window of understanding into the responses of the whole class.

The third and last quantitative unit in this mixed-method study was the second reflective Cog (cog 6) survey question, where students asserted the role that the Cogs played in their preparation for the critique. Two students out of the class selected “Other” as an option, and I requested permission to use their follow-up responses for further clarification.

I referred to tutors’ perceptions about the quality of the students’ designs and design reasoning during the critique, as expressed in their interviews. The tendency identified was corroborated by referring back to my observational notes and using open coding to identify what physically transpired in the studio after the design critique.

The hypothesis formed at that junction was that an irregularity existed between the more practical aspects of the design versus its aesthetic/creative value as perceived by the tutors.

I consulted relevant literature in search of a suitable analytical framework to test the hypothesis. At this point the underlying research focus shifted to understand why the irregularity between the practical and creative aspects of the design occurred. This led to the thematic analysis of the QUAL data collected.

### 3.6. Research procedure

Figure 3.6 clarifies and summarises the procedural steps taken in the research process and the data consulted at each step. As mentioned earlier, the steps are based on those Withell and Haigh’s (2014) followed for their research retrodution.

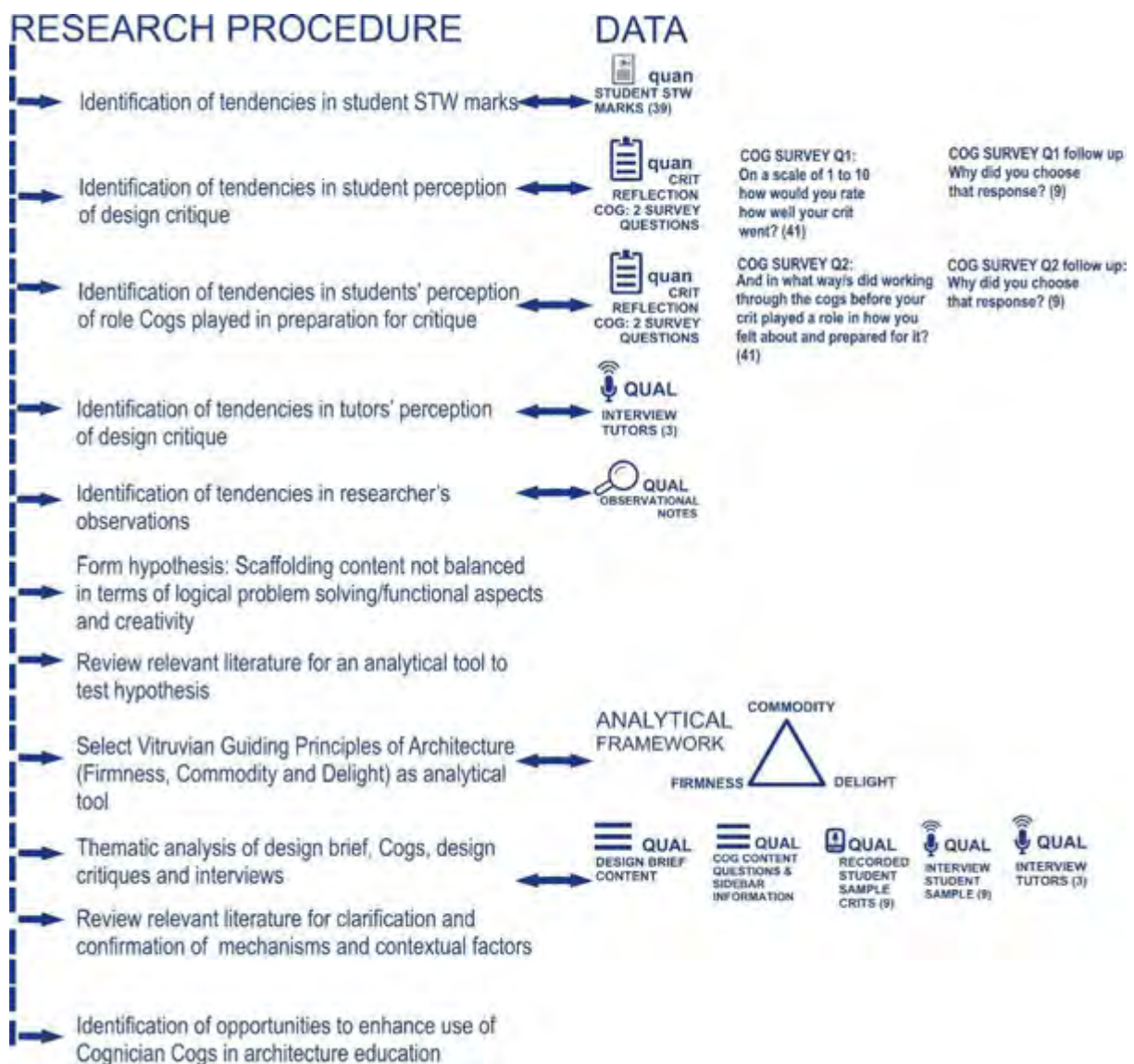


Figure 3.6. Research procedure

### 3.6.1. Thematic analysis

To test the hypothesis of the perceived imbalance between practical and creative scaffolding, the design brief document, Cog scripts, design critique transcripts and interviews were analysed using thematic analysis. Thematic analysis “is a data reduction and analysis strategy by which qualitative data are segmented, categorised, summarized, and reconstructed in a way that captures the important concepts within the data set” (Ayres, 2013:3). Thematic analysis can be conducted in a bottom-up or top-down manner (Ayres, 2013). In this instance the theoretical (top-down) approach was used to organize data according to the Vitruvian virtues for architecture, translated for this study as Firmness, Commodity and Delight.

Excel was used as a data analysis tool to map the data under these three broad ‘architectural virtues’. Various subthemes emerged under each main theme, as portrayed in *Figure 3.7*.




*Figure 3.7:* Emerged themes and subthemes

Table 3.1 provides an example of how thematic analysis was applied. The data reference codes are also captured.

Table 3.1. Example of how thematic analysis was applied

**Data Reference:** Survey Questions = **SQ** (1 or 2), Project Brief = **PB**, Cog Prompts and Sidebar Info: **FC**= Function Cog, **EC** = Ergonomics Cog, **AC** = Activity Cog, **MC** = Materials Cog, **CC** = Construction Cog, Design Critique = **C** (Example CS3TD = Critique Student 3 with Tutor D), Student Interviews = **SI** (-1,2,3,4,5,6,7,8 or 9), Tutor Interviews = **TI** (-A, B or C),

Utterance	Data Ref	Firmness		Commodity		Delight	
TUTOR C: While they were designing? As I say, I think the conventional students were taking from only what they know, there was no creative process or not a big creative process, it was just kind of taking from a historic, something that they have seen before and then kind of just manipulating that into kind of how the brief stated and then the other students that looked at all these different aspects, materiality, ergonomics, adaptability of the structure, there was definitely more creativity, more of a creative process.	TI-C:74-84	1 Materiality	1 Structure	1 Ergonomics		1 Convention (conventionality)	1 Convention (uncreativity)
Sidebar 101: The importance of construction: In true over-the-top fashion, Tommy Hilfiger's Prep Tour pop-up shop is a lavish and luxurious affair with postbox, picket fence and all. While the construction of your pop-up shop may not require an army of builders to roll out the faux lawn and make an entire family home appear from nothing, your construction requirements are just as important, and need to be considered not at the end of the design process, but reflected on the whole way through. <a href="http://www.youtube.com/watch?v=T1rfnXV75uA">http://www.youtube.com/watch?v=T1rfnXV75uA</a> 	CS3TD:27-33	2 Materiality	2 Construction	1 Display-ability	1 Activity	1 Appearance (Aesthetics)	1 Appearance (Appearance)



### **3.7. Validity and ethics**

Maxwell (2008) provided guidance on how to ensure the validity of this study, and highlights bias and reactivity as the two main threats in research that is predominantly qualitative in nature. Maxwell defines bias as: “ways in which data collection or analysis can be distorted by the researcher’s theory” (2008, p. 243). Reactivity refers to the influence a researcher could have on the subjects of the study.

My mixed methodology allowed for the implementation of various of Maxwell’s validity-securing techniques, such as “rich data” (through interviews and observational notes) and triangulation of participant experiences. During the thematic analysis I used quasi-statistics to avoid drawing unfounded conclusions. For verification my supervisor reviewed my data analysis files and coding and I also consulted with a lecturer in architecture about the accuracy of the conceptual analysis. Due to the subjective and intuitive nature of utterances in the “delight” theme, I was careful not to conflate the different issues that emerged. I countered this by adding another layer of sub-themes to make my conclusions more transparent.

To further limit potential bias in this study, I was not involved in the development of the Cognician cogs. Moreover, as Tutor A was involved in the Cog development two more tutors were brought in to conduct design critiques in order to balance her feedback on the intervention.

To combat reactivity participants were asked to be candid when they provided input. During a face-to-face introductory session with the students it was brought to their attention that neither Tutor A nor the researcher was affiliated with Cognician company. It was stressed that they were interested in students’ honest feedback on their experience using the Cogs as part of their design process. Apart from Tutor A, the tutors were not shown the Cogs

beforehand nor did they have knowledge of what the Cogs could contribute to the design process. The tutors too were asked to provide only forthright accounts of their experiences.

### **3.7.1. Ethical considerations**

As a UCT student I had to obtain consent for this study from the UCT Research Ethics Committee. I also sought permission from the specific university to conduct research on their premises and with their students as subjects. Permission for this study was granted by Deputy Vice-Chancellor (Academic), with support from the Dean of the Faculty at the study site (Appendix C).

I also requested specific permission from all students attending the block week to use transcripts from the Cogs; from nine sample group students to audio record the interviews with them, to audio record design critiques that they were involved in and to use their Cog scripts; and from the four tutors involved to audio record their interviews and to audio record the design critiques they conducted with students from the sample group.

Consent forms (Appendix C) were presented for them to sign and they were made aware that their inputs were voluntary and would be dealt with confidentially. They were also advised on numerous occasions that they could opt out of the study at any point should they chose to do so.

During my data collection time the student participants moved around between working spaces, and I could not secure permission from all for the use of the Cog transcripts. With permission from their lecturer I returned to the studio during their next block session (block 4) two months later, to obtain consent to access and use the Cog scripts for the whole class. Only once permission was obtained from all students did I request that Cognician supply me with the transcripts of student responses to the Cogs that were stored in the backend of the system.

### **3.8. Chapter summary**

This chapter presented the argument for decisions made in the design of the research methodology for this study. The key methodological decisions were made to accommodate a focus on the design learning process and studio-based classroom complexities. A critical realist stance was taken to understand the ways in which and under what circumstances Cognician Cogs may scaffold architecture students' conceptual design process. A mixed method was the type of research employed, mostly relying on qualitative data, but also including some quantitative data collected from three survey questions included in the reflective Cog and the Studio Work marks. Qualitative data were collected through the recording and transcription of semi-structured, face-to-face interviews with lecturers and students and the design critique conversations between them. Field notes from my observations were also included in the qualitative data. Ways in which qualitative data were analysed thematically were explained in detail. Issues of validity and ethics were also explained.

## **Chapter 4. Findings and Discussion**

### **4.1.Introduction**

This chapter deals with the mode of inquiry and analysis of the data collected for this study of the use of Cognician Cogs as scaffolding tool for conceptual design in architecture. The study findings are presented in the following order: the Cogs' influence on summative student outcomes followed by the Cogs' contribution to the scaffolding in each of the Vitruvian guiding principles of architecture: Firmness, Commodity and Delight and finally the Cogs' role in students' formulation of 'design intent'.

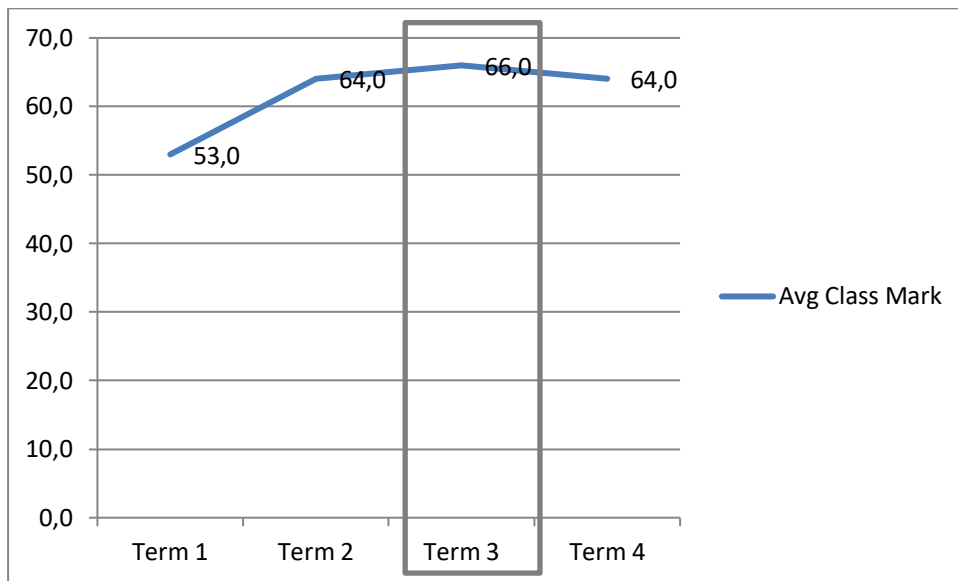
### **4.2.Data analysis**

Primary research insights were gained through qualitative data analysis. A process of thematic analysis was conducted in Excel to categorise qualitative data according to the Vitruvian guiding principles of architecture. Various subthemes emerged under each of the Vitruvian principles, but due to the space limit for a minor dissertation only the three most prominent subthemes are presented. Quantitative data from the whole architecture class in the form of Studio work marks and responses to closed survey questions provide supportive evidence in this mixed-methodology study.

### **4.3.Concept development: Summative student outcomes**

A first point of inquiry was whether the use of the Cogs revealed a trend or irregularity in the summative student outcomes for Studio work in term 3. To this end the marks for the 39 students, as provided by the course coordinator (Tutor A), were analysed. First the class average obtained for the third-term Studio work project was compared to averages achieved

for other terms. This comparison shows a class average of 53% in term 1; 64% in term 2; 66% in term 3; and 64% in term 4, as seen in *Figure 4.1*.



*Figure 4.1.* Average class marks for Studio work, terms 1 to 4.

The average term marks reached a peak of 66% in term 3, when the Cogs were used (marked in grey in *Figure 4.1*). Although the average term marks link the 2% increase from term 2 to term 3 to a possible effect of the use of the Cogs, it can be deduced that overall the use of the Cogs did not negatively affect the class average.

To establish whether there were any subtle differences in student performance within the class, further analysis sought to compare the performance of lower-, average- and higher-achieving students for this project compared to other term marks. To this end the class was divided based on their final mark (FM) for the year (calculated from all four terms). The resultant graph (*Figure 4.2*) represents the eight lower-performing (50.0-59.9%) students in green, the 24 average-performing (60.0-69.9%) students in red, and the seven higher-performing (70.0-79.9%) students in blue across four terms.

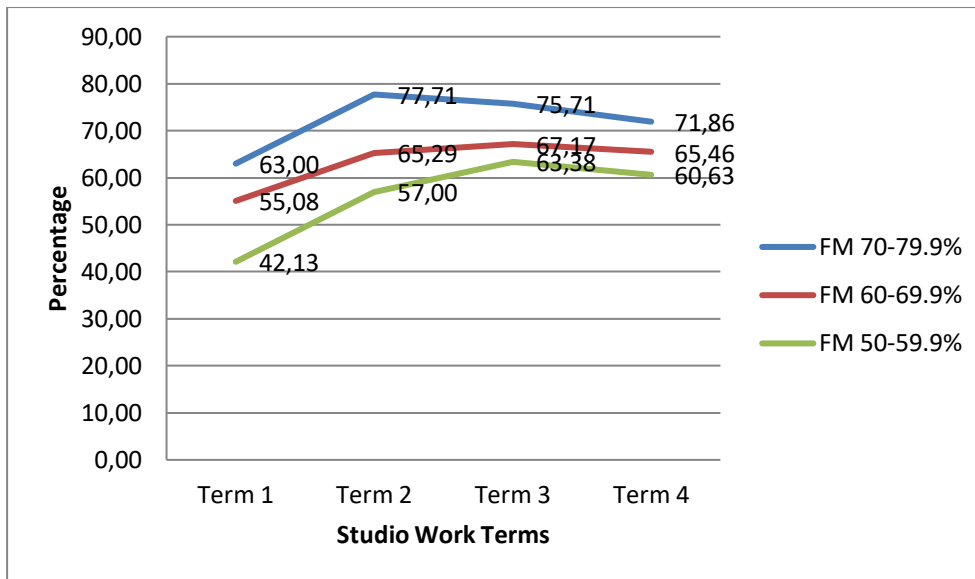


Figure 4.2. Higher-, average- and lower-performing students' Studio work marks

An irregularity is visible for the term 3 marks obtained for the project in which the Cogs were used. The lower-performing students, who on average performed in the 50-59% bracket (green), show a sizeable increase of 6.38% in their marks, while the higher-performing students show a decline of 2% in their performance. The average-achieving group's marks (red) also increased slightly for this project, with a 1.88% rise. The marginal improvement for the average-achieving group is slightly below the 2% class average increase for term 3.

From the similarity in the overall increase and decrease of project marks from term 1 to term 2 and again from term 3 to term 4, I deduce that the Cogs may have contributed to the change in student learning outcomes in the research project term, most specifically pertaining to the marks of the higher- (more expert) and lower- (more novice) performing students. This 'equalising' effect could be interpreted as the Cogs being more successful in scaffolding the assessed performance of more novice designers in the class, whilst possibly hindering students with more design expertise in their summative design project. Tutor A also alluded to this possible effect when she shared her observations after assessing the final project with

another lecturer: “I get a sense that it definitely helped the less-prepared students more than it probably helped the better-prepared students” (TI-A: lines 103-105).

#### **4.4.Scaffolding of the Vitruvian guiding principles of architecture**

This arrangement of findings relates to the contribution of the Cogs in scaffolding the Vitruvian guiding principles of architecture: Firmness, Commodity and Delight. To obtain these findings qualitative data (project brief, Cogs, sample design critiques, sample student interviews and tutor interviews) were thematically analysed using the Vitruvian triad as main analytical themes. The data comprised 5502 lines (56 202 words), nine images and eight videos. The main themes ‘Firmness’ and ‘Delight’ emerged as fairly similar across the spectrum with 231 and 221 coded items respectively. ‘Commodity’ followed, at a lower 185 coded items. As illustrated in Figure 4.3, ‘Firmness’ produced the most subthemes (12), of which ‘Materiality’ was the most mentioned (61). Six subthemes emerged under ‘Commodity’, of which ‘Functionality’ was the most prominent (56). Thematic analysis of ‘Delight’ also revealed six subthemes, ranging from ‘Form’ with the most mentions (83) to ‘Appearance’ with the least (19).

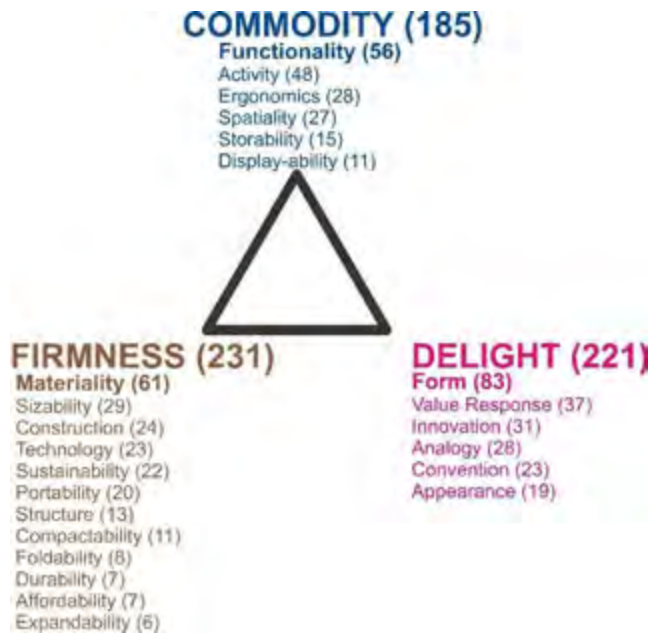


Figure 4.3. Emerged themes and subthemes

As mentioned earlier, due to the space restriction only the three most prominent subthemes will be presented in more depth. To stay true to Vitruvius’ articulation of the triad, findings are presented in the following order: Materiality (under Firmness), Functionality (under Commodity), and Form (under Delight).

#### 4.4.1. Cogs’ contribution in scaffolding Firmness

In Figure 4.3 the Vitruvian principle of Firmness subthemes that emerged across analysed data are shown. These Firmness subthemes include Materiality (61), Sizeability (29), Construction (24), Technology (23), Sustainability (22) and Portability (20). Less frequently observed themes were Structure, Compactability, Foldability, Durability, Affordability and Expandability, each receiving were between 6 and 13 mentions.

##### 4.4.1.1. Materiality

More than a third of utterances about Materiality were made in the design critique (24/61), and almost a third (19/61) came from the Cog content. The student and tutor interviews



contributed 10 and 4 mentions respectively, with the project brief only accounting for a single mention.

In the **design critiques** sample group students were generally quite prepared to talk about the materials, listing local availability, light weight, durability and sustainability as their main selection considerations. Material types mentioned include tubing, crates, pallets, timber, sandbags, cement, polystyrene, paint, leather, mesh, plastic sheeting, plywood, steel, laminated floor, mirrors, canvas and glass. Four of the nine sample group students initiated the discussion around materials without being prompted. Tutor scaffolding around ‘Materiality’ in the critique was typically to prompt students to reconsider heavier material options (steel, glass and plywood) for portability reasons, but also in some cases to suggest local materials more readily available in the Wuppertal context:

Tutor C: I think you should definitely go and research some more materials perhaps ....  
I’ve been telling it to a few people ... go and research the local materials. What is manufactured there or just even South African materials, what new, lightweight materials there are...(CS7TC:95-104)

It is not surprising that the most Materiality utterances (15/19) in the **Cogs** were located in the ‘Materials’-themed Cog. This Cog included two videos, one covering the physical properties of materials primarily in terms of suitability, sustainability, weight and durability. The other video focused on eco-friendly materials. The videos carried a number of examples of material types. Although sustainability emerged as its own subtheme, mentions around environmental impact of the pop-up shop were in most cases directly related to Materiality, more specifically perceived eco-friendly material types. Apart from appearing in a list, the link between the material weight, locality, transport and sustainability was not very clear.

Sustainability appeared 12 times in the Cogs, with a very dense representation (9/12) in the two Materiality-focused videos and text under those videos in the Materials Cog specifically. An example of this is the supporting text in the Cog sidebar under one of the videos: “Key terms to consider when you’re choosing the materials for your pop-up shop are ‘eco-friendly’ and ‘sustainable’...” (MC:58-77).

Ten (of 61) Materiality utterances were made in **student interviews**. Students 3, 4 and 9 didn’t mention Materiality in their interviews. Students 1 and 7 felt that the questions about Materiality in the Cogs were too early in the design process; they would have preferred to have developed a concept first: “... because when you have got an idea, you can start thinking about what materials will work for you” (SI-7:62-70).

Student 2 pointed out that the precedents pertaining to eco-friendly materials or even materials in general were not appropriate for the Wupperthal context. He complained:

... it’s definitely not local enough. Definitely, definitely not ... So if there’s like a group of people ...They make things out of recycled materials. Plastic lids that they go walk around and make shower things.. You know if you start throwing that precedent at us we will understand that it is for the average Joe, you know (SI-2:518-525).

Students 5 and 6 stated that the materials they selected in the Cog didn’t need to be changed after the design critique. Student 8 said that the Materials Cog had the most influence on her design, specifically in terms of ensuring a lightweight structure. She also mentioned that one the weaknesses of her design identified in the design critique was that the materials she was considering would most likely not be available in the Wupperthal context.

Materials were mentioned only four times in both the **tutor interviews** and the project brief. In tutor interviews the words ‘materials’ and ‘materiality’ were mentioned as part of a list of design informants which Tutors B and C felt students considered or were constrained by, as

illustrated in this comment from Tutor B: "... it must be this size, it must be this material, it must be this, this, this, this... one often gets stuck on those issues" (TI-B:90-100).

The single Materiality mention in the **project brief** relates to criteria set out for the pop-up shop suggesting that it should be "sustainable" and that materials should be "relatively lightweight" and "durable" (PB:93-94).

The Cogs provided extensive Materiality scaffolding, but too early for students' design process. Some students articulated they would have preferred to have developed a concept first. Through the Cogs students were prompted to commit to material specifics fairly early on in the conceptual phase, and some students had to reconsider their choices after the critique. Tutors didn't explicitly refer to shortcomings pertaining to students' consideration of Materiality. However, this may be due to students being proactive and talkative in their design critiques about Materiality details.

Despite tutors not mentioning challenges with Materiality in student designs, the critiques revealed issues, especially concerning the locality and portability of students' material selections. This finding is reiterated by student interview data. A student pointed out that the material precedents presented were not local enough. Material locality issues were further exposed by Tutor C's statement that he had advised a number of students to do more research on local materials.

The unsuitable material varieties that students listed in the design critiques in many instances corresponded with the material examples prompted in the Cogs, such as plywood and mirrors. It seemed as if material examples presented consider universal material types, neglecting locality. The Cogs also introduced a strong sustainability agenda, especially through the featured videos. A reason for this could be that globally issues of sustainability are high on the agenda, and the Cog content compiler was able to locate more readily available short videos on materials through the lens of sustainable choices. Sustainability was, however, only

one of three criteria in the design brief; the other two, durability and weight, received considerably less coverage in the Cogs. A direct implication of insufficient reasoning around the weight of materials was that a number of student designs identified heavy materials, thus affecting portability and eco-friendliness in terms of the carbon footprint for getting the pop-up shop onto location.

#### **4.4.2. Cogs' contribution in scaffolding Commodity**

For the Vitruvian principle of Commodity in architectural design, the subthemes that emerged were Functionality (56), Activity (48), Ergonomics (28) and Spatiality (27), Storability (15) and Display-ability (11) (Figure 4.3). As third most prominent subtheme overall, and highest under the Commodity main theme, the Functionality findings are presented and discussed more in depth.

##### **4.4.2.1. Functionality**

Functionality received a fairly equal number of mentions across design critiques (13), student interviews (13), Cogs (11) and the project brief (9). In the tutor interviews Functionality was mentioned 6 times.

The **design critiques** offered 13 mentions of Functionality. The conversation between Student 2 and Tutor A contained most mentions (4/13). Student 2 didn't focus on selling something specific: he wanted his prototype shop to be used by different shopkeepers in the community. Student 6's shop was intended to function as clothing retail and alteration space. Elements of Student 5's shop were designed to have multiple functions. Student 8 proposed a box-shaped design that would provide the needed Functionality for movement, ventilation and lighting. According to Tutor D, Student 3 neglected Functionality; likewise was Tutor A's critique of Student 9's design. Student 7 mentioned Functionality only in relation to the products she was planning to sell. Function was not explicitly mentioned in the design critiques of Students 1 and 3.

In the **student interviews** (13) Functionality mentions indicated that for most sample students the Function Cog was either most useful (along with Activity and Ergonomics) or timeous in this project. Student 7 clarifies why these Cogs were more useful to her: “the Function and the Ergonomics [Cogs] because you don’t really need a design or anything like that to answer those questions, but the other stuff like the materials and you can only give a general answer” (SI-7:62-70).

Student 9 agreed that the Function Cog prompts were still valuable, even if used without a design idea. Student 8 suggested that the Cogs helped his design in a practical and functional way, but might have hindered his creativity. Student 6 said her design’s functionality was deemed satisfactory in the critique, but not its Form.

Four sample students said the Cogs went into function detail too quickly, and three said they would have wanted to develop an idea first. Student 9 proposed that content on how the separate parts of her design could be integrated would have helped. All nine sample students stated that they preferred the five Cogs as separate themes rather than different themes combined, as it made the content “more logical” (SI-3:76) and “easier to deal with” (SI-4:201).

Eight students followed the set order of the Cogs, with Function first followed by Ergonomics, then Activity, then Materials and lastly Construction. Student 3 stated that she opted to do the Function Cog first because “Form follows function” (SI-3:58-67). Student 2 was the only student in the sample group who did not do the Cogs in the intended order. He opted to start with Ergonomics, because the concept was new to him. As in the Materiality theme, Student 2 also pointed out that the Cogs lacked contextual Wupperthal information and relevant precedents. He proposes that for student designs to function successfully in the Wupperthal context, they should be scaffolded to more closely relate to the vendors in that area. He suggests the following added multi-media for the Cogs:

“Take it to Wuppertal ...Go show us a video of someone in Wuppertal ... Walking there with his fruits. And no pop-up shop and we know, okay that’s the guy who wants a pop-up shop” (SI-2:531-555).

Eleven **Cog-related** prompts on function were located in the Function, Ergonomics and Materials Cogs. The Function Cog was the first in the line of the five Cogs on a horizontal scrolling landscape, and the first question prompt in the Function Cog was: “What will your pop-up shop be selling?”. Other prompts related to functional requirements and there was also a short video on a Hong Kong-based precedent using moving walls to increase functionality in a small space. In the Ergonomics Cog, function is covered twice in relation to user-friendliness. A green materials video includes prompts on function as a material selection criterion.

The **project brief** contains nine mentions of function. The two in the introduction refer to the global function of a pop-up shop: “temporary retail spaces that sell merchandise of any kind” (PB:101-1-2), and a contextualised mention of the types of merchandise to be sold in Wuppertal: “rooibos tea, leather goods, arts and crafts” (PB:98-99). Function was mentioned three times as a project priority or outcome. It was stated as follows: “The focus of the project is on function and technology (and less on context)” (PB:131-132). Functionality was also mentioned twice in relation to its influence on the form of the design. The “Thinking about Function” (PB:146-162) section provided prompts for students to think about function in relation to anthropometrics (1) and structure (1).

During **tutor interviews** Tutor B was responsible for 5 out of the 6 total mentions of function. In his opinion, student designs were functionally suitable, but not creative. His theory was that students focus on satisfying the project brief criteria to the detriment of innovative design:

Tutor B: The students were all quite clear on those functional requirements ... it would be something that would have worked for the purpose that it was designed for, but as a creative design object, it was lacking ... there are lots of functional criteria that one often gets stuck on those issues and don't always focus too much on the aesthetics, but that is your first impression, but if they come to you with a bad design then, yeah (TI-B:63-100).

Although Tutor A did not explicitly mention function, when asked about students' incorporation of the Cog themes (which included function) into their designs, her response was that all the students she critiqued were able to engage with and talk about those aspects of their designs.

Students were satisfied with the level of Functionality scaffolding provided by the Cogs. Students felt that their preparation in terms of Functionality was mostly sufficient, allowing them to work on other aspects of their design (like form) that, from tutors' viewpoints, were less successful. Student 6 said: "I didn't have to worry about the function because I had already tackled that, ... but they also focus on the design [form]..." (SI-6:269-279).

The Functionality Cogs along with the two other predominantly Commodity-themed Cogs, Activity and Ergonomics, were all indicated as the most useful Cogs from the students' perspective. Although some students mentioned that Functionality scaffolding was too detailed, and one student felt that Functionality was not contextualised enough, the overall verdict was that the support was timeous in relation to their design process.

Tutors made very little mention of Functionality in the design critiques, and there were very few examples of corrective scaffolding. Tutors stated that they were satisfied with how students considered Functionality aspects, but their satisfaction with functional aspects of students' designs was greatly overshadowed by their disappointment with the conventionality

of student designs. In contrast, Functionality was highlighted as one of the two (along with Technology) most important aspects in the project brief. This implies a misalignment between the brief and the design critique agenda.

#### **4.4.3. Cogs' contribution in scaffolding Delight**

Form, Value Response, Analogy, Convention and Appearance all emerged as sub-themes under Vitruvius' Delight principle (Figure 4.3). Across all of the data collection instruments, Form accounted for 83 mentions, Values Response 38, Innovation 31 and Convention 23. Issues concerning Analogy and Appearance produced 28 and 10 mentions respectively. Form refers to all contour aspects of the design, such as shape, enclosure, etc. As the most prominent Delight subtheme, Form will be discussed further.

##### **4.4.3.1. Form**

Findings of the key contribution of the Cogs in scaffolding the principle of Delight through Form was gathered from all of the data sets to represent scaffolding in the blended studio. Findings are presented from highest to lowest mention frequency of the term 'Form', namely design critiques, student interviews, project brief, Cogs and tutor interviews.

Of a total of 83 utterances on Form, 55 were located in the **design critiques**. More than 40% (24/55) of these referred to a box shape. Words such as "square", "box", "cube" and "container" were all coded under Form. Tutor B critiqued Student 1's design as being too similar to a container and Student 6's design was compared to "a container on wheels" (CS6TC:73-76). Students 3, 8 and 9 all self-proclaimed their designs as "box-like" during their critiques. Student 4's design was a box that transformed into something else, but Tutor A questioned the necessity to start with a box shape in the first place. Tutor A's suggested remedy was to use much smaller modular boxes with which to create a different, larger shape. Tutor C critiqued Student 5 for also being bound by a box shape and suggested something



similar, namely smaller geometric shapes used together to create a more organic form. Tutor B advised that the clever use of two rectangles could help Student 1 have a less square design. During the **student interviews** the term ‘Form’ occurred 9 times (9/83) in total. Only Students 2 and 5 didn’t explicitly mention form in their interviews. Student 9 observed that most of his peers opted for a box-like design, and despite making an effort to create a different shape his design was also critiqued as being “too boxy”. He suggested that the size prescribed in the project brief forced the design into a box shape. Student 8 said that once he saw the prescribed dimensions he immediately had a design in mind: “we got the brief and she [Tutor A] said she wants something 1.8, 1.8 by 2.5. I said, doof, I have something ...” (SI-8:33-43).

According to Student 7, the unplanned tutor intervention (a post-critique PowerPoint presentation featuring a diversity of structure forms) was helpful, as “everybody” had a “boxy design”. His response to why he thought that was the case was as follows:

Student 7: Because in the beginning of the brief they gave us a standard box size and everybody stuck to the box.

LH: Did they say box, or is that how ...

Student 7: They gave us a height, a width and a length, so they basically gave us the size of a box and said that’s your size, so everybody stuck to it and it became more building like or box like or plain and they didn’t want that so they changed it (SI-7:80-99).

Student 6 suggested that an “additional design Cog” (SI-6:237-252) and supplementary precedents in the sidebar potentially could have improved the “outside of her design”. Student 1 proposed that a “Form” Cog could be added to the series of Cogs. Student 4 was eventually delighted with the form of his design, despite initially not understanding what

design intent was. When queried further he clarified that this insight did not come from the Cogs, but from a post-critique prompt that Tutor A posted in the class Facebook group.

Form received seven mentions in the **project brief**. One of these was a seminal reference as the main object of the project: to foster “an understanding ... of the influence that technology and function can have on the form of the final design” (PB:177-178). Form was also included into two of the seven Studio Work outcomes for the project: firstly as “investigating enclosure” in relation to space definition, and secondly as an understanding of the impact of ergonomics, function and technology on the Form of the design (PB:188-198).

There was only a single mention of variety in the form of a pop-up shop design in the project brief:

“And they come in all shapes and sizes” (PB:104).

The project brief also included two (2/7) images of pop-up shop precedents, and as seen in *Figure 4.4* both are box-shape designs.



*Figure 4.4.* Pop-up shop precedents in project brief

Student 2 explained the potential implication of the trend in visuals selected for scaffolding in this project:

When it comes to precedent studies, they mustn't show us these new age models, these mobile homes if it's not what they expect ... you show someone something like that, that stays in their head ... they get trapped in that, you understand (SI-2:459-474).

In **Cog content** form was noted six times, and only in multimedia content in the sidebars of the Function, Activity and Construction Cogs. These images, as seen in *Figure 4.5*, include images of a pushable cart, temporary retail space in a mall, video footage of the creation of a pop-up shop in a room, a small Hong Kong-based apartment, and the building of a small house-like pop-up for Tommy Hilfiger. In five out of the six occurrences the forms observed in images and videos were box-shaped. The ‘other’ shape observed was in a video about an augmented-reality pop-up shop in the shape of a Nike sneaker.



*Figure 4.5.* Pop-up shop precedents in Cogs

The five form mentions counted in **tutor interviews** came from Tutors B and C and captured their disappointment with the box-like appearance of most of the student designs they observed. Tutor B, guided by the ‘prescribed’ size in the project brief, admitted to also initially thinking that the design should be square:

Yesterday’s designs generally were a little bit disappointing, ... they were all too similar and I think it was because the students took the size of the unit given as a box

within which they had to design, so we ended up with 38 students all having exactly the same shape structure (TI-B:18-28).

Tutor C proposed that the prescribed size was one reason for the boxy design phenomenon, and in addition speculated that students went with a “gut” feeling of what a pop-up shop should be rather than engaging with the separate elements:

It felt like about 40% of the students I saw yesterday, looked at those in detail, the ergonomics, material used, how it relates to the context, like those kind of fundamental issues and where some of the other students just went by a gut feeling of what they think and that is where the more conventional designs came from. It’s just kind of taking from what they know and that is the vendor on the street that can move his truck and that is a box you design (TI-C:61-73).

Tutor A had a more moderate response, but agreed that designs were not yet at an innovative level. Students felt that form and “design” were absent in Cog scaffolding. Tutors highlighted the biggest issue in the project as the dominance of square student designs. Novelty in terms of the form of designs was not set as an objective in the project brief, whilst data from the design critiques, tutor and student interviews indicate that it was a tutor expectation. Tutors B and C were more vocal about their disappointment with the frequent occurrence of the box shape in student designs. Tutor A was involved in the Cog development and therefore had a broader understanding of the possible contribution of the Cogs in the blended learning design of this project. It is unclear whether tutors were expecting diversity in form from the outset of the project, or if the fact that most students produced a square-shaped design triggered the tutors’ desire to see a different form. One might argue that as students in a design course, a creative output is an obvious expectation. As novice designers, however, the students’ creativity awareness is probably still emerging.

There were different perceptions as to what led to the box shapes, the most frequently cited by students and tutors being that the brief prescribed a size interpreted as a box. A second observed reason for the monotony in the shape of designs was that the precedents included in the project brief and Cogs were typically box-shaped. The project brief provided two such images, and the Cogs further expanded on this. The Cog content provided six pop-up shop precedents, of which five were box-like. As observed in *Figure 4.5*, the sixth cog-related precedent was not box-like but was an augmented-reality Nike pop-up shop. Although it was very imaginative, it promotes online shopping and is therefore not suited to the kind of rural trade implied in this project.

The box-like pattern in precedents could have limited thinking around form to similar shapes. This observation, supported by data from the project brief and Cogs was reiterated by Student 9 in his interview:

... initially, I didn't have anything in mind because everybody had this box with that container; there is a container on the briefs ... There's a container where a question has to go in [Cog prompts],... That's the only thing I could think of ... (SI-9:59-88).

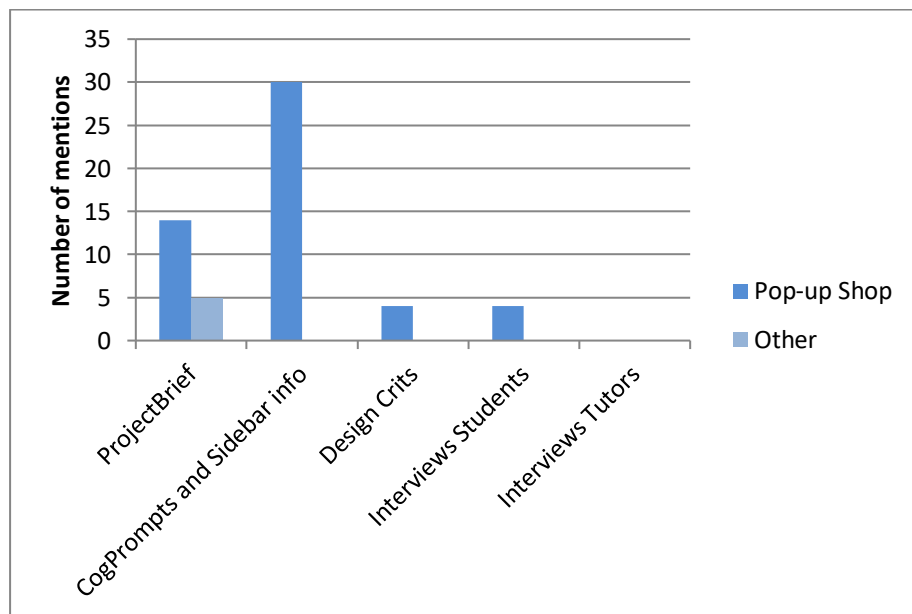
Both Tutors A and B were trying to direct students to different, more organic shapes potentially more suited to the rural context.

Another noteworthy observation was that throughout this study as researcher I often performed Google image searches under the search term 'pop-up shop' – which in every instance produced an overwhelming number of box-shaped precedents on the results pages. The visuals of pop-shops in the project brief, Cogs, and what I observed from my search engine results, were quite urban: bold, square, and often a more conventional permanent structure temporarily changed into a shop. However, this is historically exactly what a pop-up shop is. The project brief describes the phenomenon: “Sighted as early as the 1990s in large

urban cities such as Tokyo, London, Los Angeles and New York City, pop-up shops and pop-up retail are temporary retail spaces that sell merchandise of any kind” (PB:101-102).

On reflection, possibly the task described in the brief was not quite a pop-up shop. If it had been labelled as a mobile vendor stand or stall, for instance, it may have opened up more possibilities in terms of relevant precedents. It can therefore be argued that the naming of the design as a ‘pop-up shop’ in the Cogs and other project documents and processes may have unwittingly narrowed students’ conceptions of a suitable “moveable shop” in a rural context.

Based on the above findings, I returned to the data to also code what appellations were assigned to the required design. As noted in *Figure 4.6*, the required design was labelled “pop-up shop” 19 times in the project brief, 30 times in the Cogs, 4 times in the design crits and 4 times in the student interviews.



*Figure 4.6.* Pop-up shop appellations

Of the total of 57 times that a reference was made to a pop-up shop, in only five instances was it as an alternative label, such as “temporary retailing” or “flash retail” (PB:98-100). The

other 52 times it was under the label of “pop-up shop”, and 30 of these were found in the Cogs.

#### **4.5.Cogs’ role in design intent formulation**

The final arrangement of findings focus on the role that the Cogs played in design intent formulation. This includes findings on students’ design critique performance and preparation and conceptual design terminology. Then findings on brief definition and prioritisation of the three subthemes Materiality, Functionality and Form in scaffolding are set out. Lastly the QUAL data from interviews are presented to address the integration of the principles of the Vitruvian triad.

##### **4.5.1. Influence of Cogs on students’ design critique performance**

In the first of the two survey questions included in the study, students were asked to rate their design critique (using a numerical slider). These questions were posed in Cog 6 (reflection Cog).

###### **4.5.1.1.quan Whole class (41)**

For the first question there were 39 responses captured out of the 41 cog users (whole class) in this project. I used the data Cognician provided in Excel format and created the line graph seen in *Figure 4.7*. The responses from the whole class (39) are represented by the blue line. The sample group (9) responses have also been included, plotted on the graph in red. The X-axis and Y-axis are, respectively, the students’ rating of the design critique and the number of students selecting a specific numerical rating.

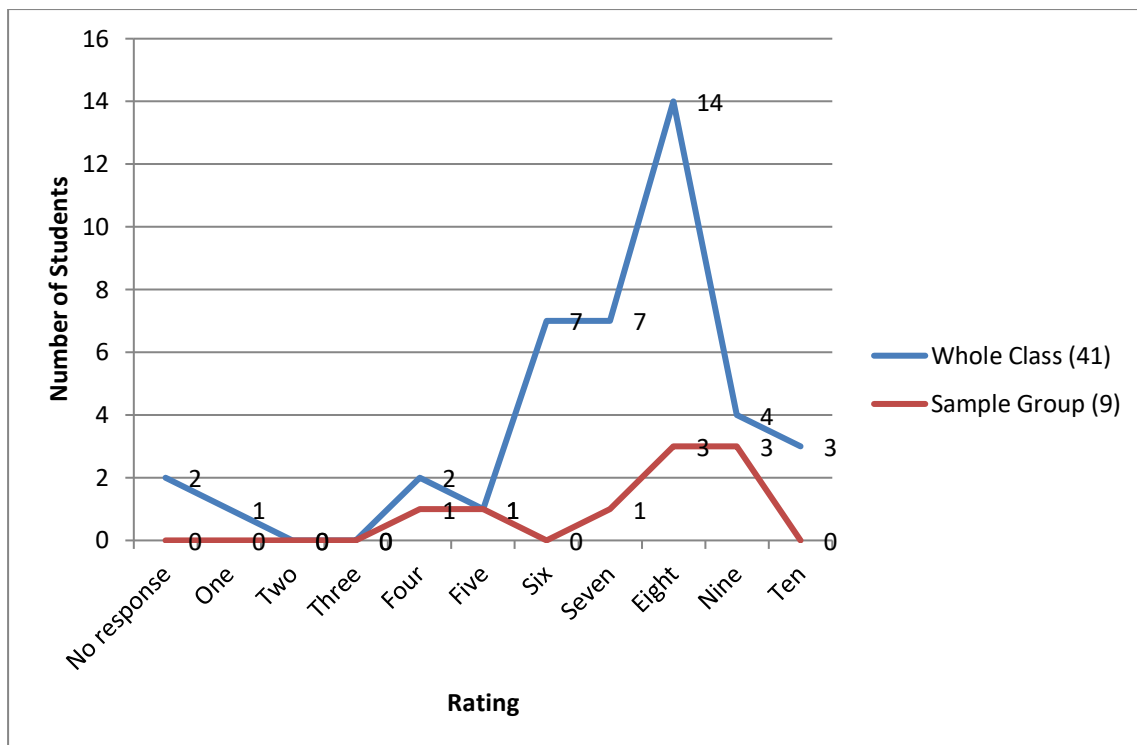


Figure 4.7. Students’ rating of their design critiques on a scale of 1 to 10

The class median for this survey is 7.26, indicating the students’ relatively high satisfaction with their “crit” overall. Most students rated their design critique very favourably, with more than 50% of the class (21/39) evaluating their session as an eight, nine or ten. About a third of respondents (14/39) scored this experience as an eight. About 10% (4/39) of students rated the critique as a five or less, and two students did not respond.

The question, however, did not explicitly refer to students’ own performance in the critique, so responses could also have included students’ rating the interaction with their tutor and/or the feedback they received in the critique. To uncover what students might have equated with a more or less positive design critique experience, the sample group responses to the follow-up (open-ended) question “And why have you given this score?” were analysed.

#### 4.5.1.2.QUAL Sample group (9)

The purpose of analysing the responses of the sample group to the follow-up question “And why have you given this score?” was to establish a tendency in reasons students provided for



their critique rating. The nine responses were compared. It was found that the two students who scored the critique lower (at 4 and 5 respectively) were not happy with what they presented in the session. One student felt the Tutor's suggestions were "not practical". Five out of the six students who rated the critique higher (at an 8 or 9 out of 10) based their satisfaction on the input and direction they received from the critique rather than their own performance.

The results from this survey question do not provide a convincing relationship between the use of the Cogs and how students rated their design critique. It might rather be indicative that students assign themselves less agency in the design critique and place a higher value on input received from tutors, rather than being cognizant of their own performance. This sentiment is supported by Student 8, who scored his design critique at 8 out of 10. He made the following comment in response to the follow-up question: "The response I received was very helpful, although if time had allowed, I would have liked to develop my design further by utilizing the knowledge and experience of my lecturer..." (SQ1B-8:8).

#### **4.5.2. The role of the Cogs in students' preparation for the design critique**

The second question included from the Cog survey was posed to prompt students to express what role they thought the Cogs played in their preparation for critique and confidence levels. In response to the question: "*And in what way/s did working through the Cogs before your crit play a role in how you felt about and prepared for it?*", students could select an option from the following options, as indicated on the X-axis of *Figure 4.8*: 'No Role, Whatsoever', 'Some Role', 'Huge Role' and 'Other'.

#### 4.5.2.1. quan Whole class (41)

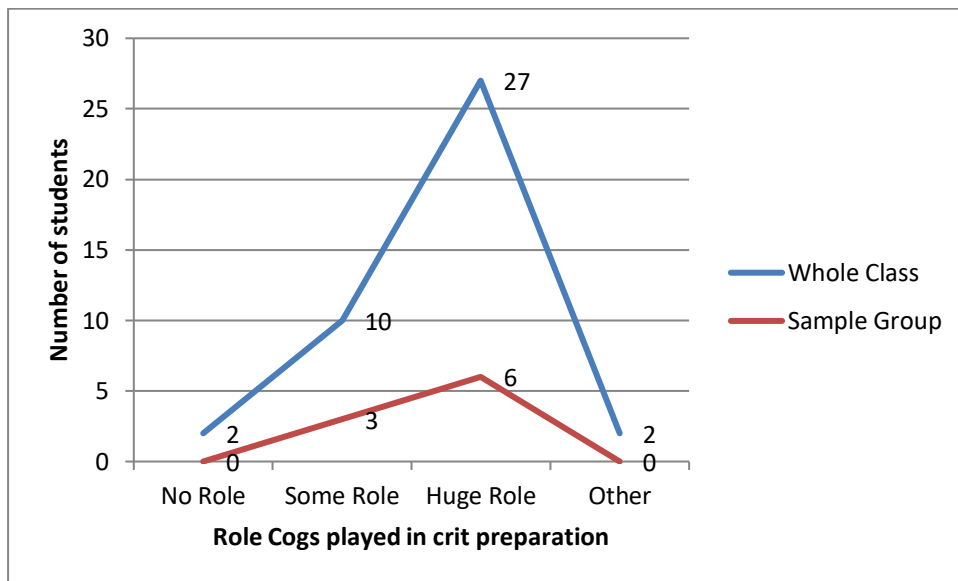


Figure 4.8. Cogs' role in design critique preparation

Two-thirds of the class selected option three, stating that the Cogs played a 'Huge Role' in how they felt about and prepared for the critique. The average score fell just below 'Huge Role' and was therefore situated at the higher end of 'Some Role'. Two students did not respond to this question and two students selected 'Other'. One student's reason for selecting 'Other' was that the Cogs provided him with a good starting point. The other student who selected 'Other' felt the Cogs didn't provide information on design intent which he needed for the critique.

#### 4.5.2.2. QUAL Tutors (3)

During interviews tutors were asked to rate students' level of preparedness for the design critique. All three tutors stated that students were mostly prepared for the design critique. Tutor A thought "they were very much prepared. They were able to talk about their research and their findings, and most students referred to the Cogs". Tutor B suggested that "probably 75% were prepared enough to actually proceed with the project". He also "thought that they had a good understanding of the brief and requirements". Tutor C "found the level quite good

[for] preparedness for a crit”. He felt that all but one of the students he saw could explain their starting points and their possible concepts in relation to what they sketched.

### **4.5.3. Conceptual design terminology**

The terms “design intent”, “design concept” and “idea” were used interchangeably by participants in in the project, as evidenced in the design critiques, student interviews, the project brief and the Cogs. In design critiques Tutors often used terms in tandem, making it unclear whether they are insinuating synonymity or referring to two different concepts. For example, Tutor C initiates a critique with Student 7 using a prompt containing “concept” and “wider idea” (CS7TC:26-32). In all three tutor interviews a version of the conflated term “conceptual idea” (TI-A:55-67; TI-B:171-184; TI: C 123-130) was used.

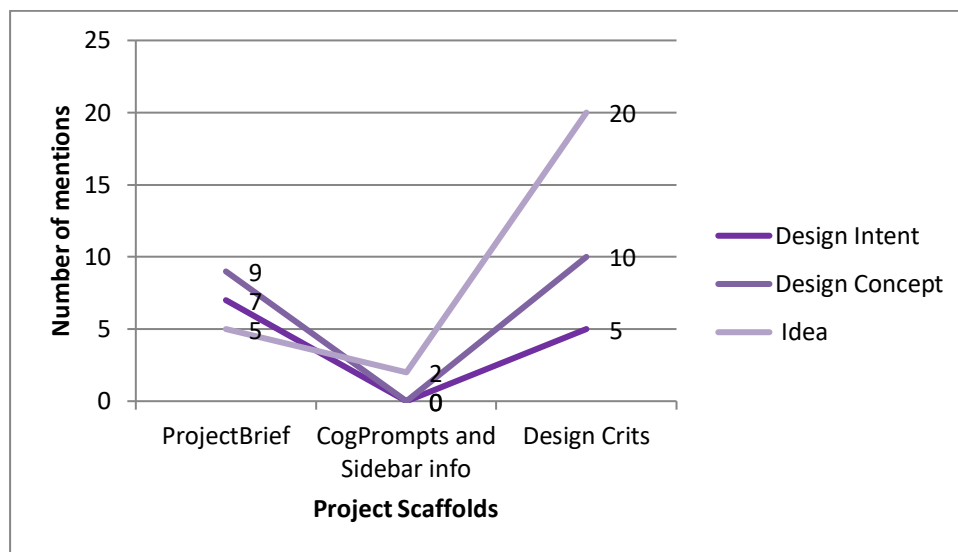
Data from student interviews provide evidence that students were confused about the terms. Student responses to the lack of definitions ranged from being confused – “it wasn’t called an intent to me, it was called an idea or something” (SI-2:57-58) – to being quite distressed. One student despaired: “I couldn’t even grasp ... to do a simple little thing ... I didn’t even know what the design intent was or proper concept was or the proper definition of concept that the lecturers were looking for” (SI-4:216-229).

In the project brief “concept” is mentioned nine times, “design intent” seven times and “idea” four times, but definitions for any of the terms were absent. An example of such a mention is: “Provide evidence of clear design idea (concept) formulation” (PB:181-182)

The project brief in lines 81 a to e (Appendix A) stipulates an expected sequence for student outputs in the conceptual phase. Students were required to first present a formulated “design intent” at the design critique, and after that to develop their intent into a “design concept”. This implies that these are two different abstractions and students are expected to deliver a different artefact for each to satisfy the brief requirements. This progression from design

intent to concept is similar to Van Graan’s (2012) notion of the progression in conceptual design documented in chapter 2.

The Cogs contained no mention of “design intent” or “design concept” and two occurrences of “idea”. The prevalence of the terms “design intent”, “design concept” and “idea” in the Cogs are plotted on *Figure 4.9*, the X-axis indicating the three separate scaffolds (project brief, Cogs and design critiques) and the Y-axis the number of mentions of each term.



*Figure 4.9.* Presence of conceptual design terminology: Design Intent, Concept, Idea

It is clear from the graph that articulation around “design intent” and “design concept” collapses in the Cogs.

The data analysis process of the terms, design intent, concept and ideas was limited to only establishing the presence of these terms in the various data sets. The quality of scaffolding of these concepts was not researched and can therefore not be commented upon. Qualitative data from student interviews, however, expose uncertainty around the definitions, which would surely complicate student efforts to meet the expected “design intent” and “design concept” requirements. The full reason provided by one student for selecting “Other” in the second Cog survey pinpoints the issue:

“The Cogs would be great prep for a usual crit, but this crit focused specifically on our design intent, which neither myself nor my classmates seemed to understand very well. This wasn't covered in the Cogs" (SQ2B-8:8).

#### **4.5.4. Cogs' role in project brief definition**

Design perspective and size constraint inconsistencies between the project brief and Cogs emerged from the Functionality and Form findings reported in sections 4.4.2 and 4.4.3 respectively.

##### **4.5.4.1. Design requirements: Perspective**

In the Functionality theme a conflict with students' design perspective was exposed. As mentioned, all but one of the sample students followed the visual linear path for the Cogs on the Cognician interface. One student (Student 2) was curious about Ergonomics and completed that Cog first, whilst the others began with Function. Student 2 also produced the only concept that could be modified and used by various Wupperthal shopkeepers. All the other students in the sample group designed a pop-up shop as if they would be the vendor. Student 2 opted to start with the Ergonomics Cog, and designed a prototype that can be used to sell a range of products. In the design critique it was implied that he had a bit of an unconventional approach to the project. Tutor A's response to his presentation was:

Are you saying that you are thinking of something that creates a starting point for the trader – so that it's a prototype ... people [shopkeepers] can personalise it, it can be used anywhere ... Because it's so simple, you have to think really hard of ways to implement it (CS2TA:29-31).

Whilst he stood out in the design critique for taking a different approach, if one compared his response to the task set in the project brief, he was designing exactly what was required as captured in the excerpt below:

The Wuppertal community approached you to design a prototype pop-up shop to optimize the tourist potential and stimulate the local economy ... A range of locally manufactured goods will be traded, including rooibos tea, leather goods, arts and crafts. (PB:L87-90)

One primary difference between the outlier and the rest of the sample group was that the rest started with the Function Cog. The very first question prompt in the Function Cog was: “What will your pop-up shop be selling?” (FC:39-49) This prompt firstly potentially assigned the designer with pop-up shop ownership, and secondly narrows that requirement to a shop only selling a certain product or product range. This aspect of altered design perspective was not picked up on in design critiques. As students were designing from an own perspective they were not necessarily required to empathise with the context, and could base decisions on their own perceived needs. To make it easier for her to “solve” the design challenge, Student 6 changed the requirements. Her response illustrates that she is not considering Wuppertal community vendors:

LH:...give an example of something that changed...while you were doing the Cog...”

Student 6: “... I was going to sell vegetables ..., the Cogs helped me think that, ... I had to focus on the function so that I can understand the final phase of my actual design. So I had to change my product that I was going to sell to make it easier to get to the final stage ...(SI-6:54-67).

The Cog order and associated prompt is possibly not the only reason why Student 2 was able to undertake the project with a community perspective. As part of his internship he was working with a designer well known for her community-focused architectural work. This

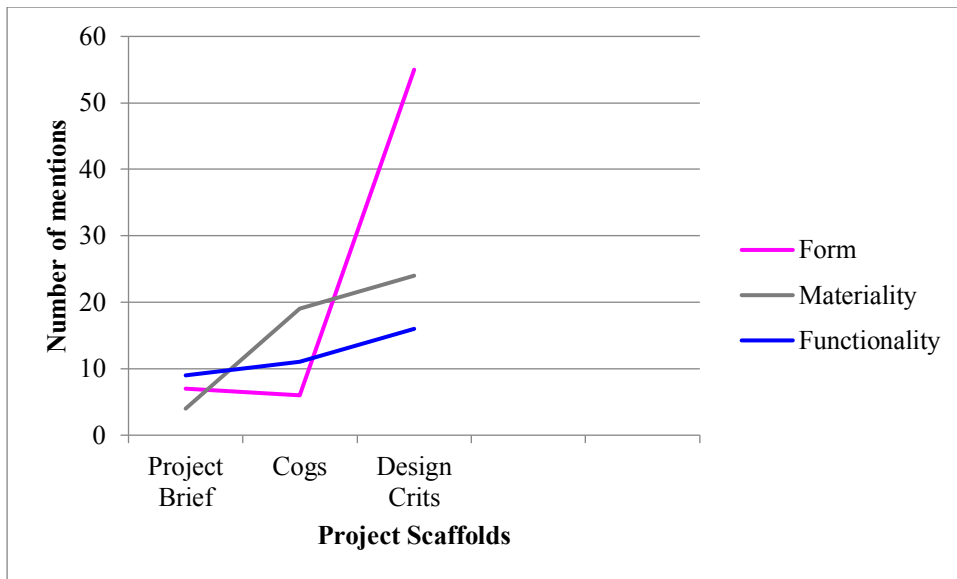
does, however, highlight that a scaffolding tool such as the Cogs has the potential to influence a designer's perspective.

#### **4.5.4.2. Design constraints: Size**

Students were all constrained by the 'prescribed' design size which some students read as a 'box-like' structure and others ended up with the same to enable the full use of space provided. Closer scrutiny of the project brief revealed that the actual stated requirement was that the pop-up shop should not "exceed 1.8m wide x 2.5m long x 1.8m high (when not in operation)" (PB:95-96). This means that technically, when operational the pop-shop may exceed this size, but also when not operational the pop-up could be smaller or stored in a different shape from the prescribed dimensions. If interpreted in this manner it would have opened up more diverse possibilities for form. The perceived size constraint had a strong influence on the resultant form of the majority of student designs, and wasn't interrogated in the Cogs or even in the design critiques. This leads to the conclusion that the Cogs didn't help students directly in clearly defining constraints set out in the design brief. Tutor C also highlighted that the shortcomings in how students engaged with the brief caused them to have: "quite conventional, very conventional designs. It was bound in imagination, there was not enough experimentation in how they interpreted the brief, I found wasn't exactly as it should have been" (TI-C:23-28)

#### **4.5.5. Design priorities: Materiality, Functionality and Form**

To compare the scaffolding of the relevant subthemes, I consulted the QUAL data from the three scaffolds, the project brief, Cogs and design critique. The prevalence of the scaffolding of the three subthemes Materiality, Functionality and Form plotted on Figure 4.10 clearly show an imbalance.



*Figure 4.10.* Scaffolding of Form, Materiality and Functionality

The scaffolding of Form (in pink) rises dramatically in the design critiques after a marginal reduction from project brief to Cog content. Materiality scaffolding (in brown) increases substantially from the project brief to the Cogs and moderately from the Cogs to the design critiques. Functionality scaffolding (in blue) shows a very slight elevation in the Cogs and a moderate increase in the design critiques. This further elucidates the previous findings that Form was under-scaffolded in the Cogs and Materiality was over-scaffolded. Functionality seemed to be more in line with the approach set up in the project brief.

The three scaffolds, the project brief, Cogs and design critiques, as indicated on the X-axis of Figure 4.10, also signpost progression in time as they were introduced in succession. If the Cogs were used as a scaffolding tool to help students from project brief to presenting their intent in the design critique, the angle of the lines should follow a more upwards angle, as seen with Functionality in blue. Instead Materiality was presented as a main priority for formulating a design intent, and Form was under-represented. The conversations in the design critiques support this observation.

#### **4.5.6. Theme separateness versus integration**



Tutor C stated in his interview that most of the students he critiqued were unable to conceptually integrate the separate elements of their designs. When clarification was elicited, he mentioned the separate elements loosely associated with two Cog themes, such as the (selling) function of the shop along with ergonomics and anthropometrics. He highlights what he thought was missing in student designs:

... the theoretical conceptual foundation for the design process ... I thought that was lacking, it's that thought process before the time and then it was just an execution of doing something thoroughly, having a constant theme throughout your design and not having all these different segments of it. (TI-C:151-156).

By contrast, all of the sample students indicated in their interviews that they preferred the Cog themes as 'separates', in other words materials-related content organised together and function-related content organised together. They all felt that integrating the content would complicate their process. In an extract from Student 2's interview he implies that students prefer less complex design tasks:

LH: ... and it [the Cogs] was broken down to five different themes. What ...if it was mixed up?

Student 2: No, too confusing ... it's nice if you're spoon-fed, you know.

LH: Okay. You want to be spoon-fed?

Student 2: Yeah, it's nice because then you, that way you can do your best and you're not hindered by not understanding, you're hindered by your own capabilities.

As students were under the impression that the Cogs were designed to fully prepare them for the design critique, they expected that working through the Cogs would produce a result that met the design intent requirement. They therefore followed the Cogs' lead without making

their own effort to integrate the different themes. As suggested already, they might view oscillating between the different themes as an uncomfortable Cognitive endeavour. Student 4 explains his disillusionment:

I thought that the Cogs were like, would help me get to the intent but I had it completely the wrong way around ... I thought that it was, that the Cogs like for example the materials and those things were intent so whichever one that you wanted to base your design on .... would be your intent (SI-4:94-104).

As suggested in their interviews, a number of students in the sample group felt that if they had a singular concept or idea prior to engaging with the Cogs, then they would have been able respond better to the various design decisions that the Cogs prompted them to make:

Student 7: We got the brief and then we were told to do the Cogs and I felt like it may have been a little bit better if we had first formulated our idea because it was a lot about function and about what materials and you have not got an idea and now you are already forced to answer these questions. But it did make you think about it, so it is good in a way, but I think maybe you should first get a design or an idea and maybe just like a basic concept and then do the questions (SI-7:24-34).

The Cogs, however, did not support students' development of an initial idea and started covering content per themes in a fair amount of detail immediately. This process of establishing an initial idea to tie the various elements together was also not supported as a face-to-face activity prior to the Cog intervention, or mentioned as an initial stage for students' process. Tutor A again highlights the conflict between gathering design information and developing a concept:

I think they were able to reflect on the procedural, I think the step towards taking that procedural knowledge or understanding and translating it into a wider conceptual idea on which to build their design from that point onwards was at the first crit not that clear, and it became clearer along the way, so I think the impact of the Cogs – and I know we are only referring to the first crit – should ultimately be measured I think throughout the process. At the first crit we expect them to have grappled with the problem, and it is rather more procedural, although we want a student to also come with an idea that is conceptual, so you have almost this tension between digesting the facts and from the research or the facts, built potential for a design concept (TI-A:55-67).

The Cogs were initially designed to alleviate the design critique from the procedural burden, so that tutors have the opportunity to engage with students on a more creative level. However, the findings show that there is a risk of neglecting the creative in the early stage of design.

#### **4.6. Chapter summary**

In this chapter I presented the most important findings in the quan and QUAL data collected in relation to the research questions set for this study. I first addressed summative student outcomes and then briefly worked through the selection of the main themes, namely Firmness, Commodity and Delight. This was followed by an arrangement of findings on the Cogs' role in students' formulation of design intent: design critique performance and preparation, conceptual design terminology, brief definition, design priorities and theme separateness opposed to integration. In the final chapter I reflect upon the entire study through answering the research questions. I also expose study limitations and provide recommendations for future research.

## **Chapter 5. Summary and recommendations**

### **5.1.Introduction**

This final chapter provides a summary of my research findings presented in relation to the research questions. It aims to expose what transpired when a scaffolding tool was implemented in a second-year architecture studio design project and identifies similarities and differences of my findings in relation to those of relevant other studies. In closing, I reflect on the limitations of this study and make recommendations for future research.

### **5.2. Summary of research questions**

The main question which this study addressed is: “In what ways and under which circumstances does the use of a scaffolding tool (Cognician Cogs) support architecture students' conceptual design?” The Vitruvian guiding principles (Vitruvius, as cited in Wotton, 1624) for architectural design, Firmness, Commodity and Delight, were used to explore scaffolding in the early design phase, specifically from students’ engagement with the project brief to their articulation of a design intent. As support extended in this conceptual phase included physical and conversational scaffolds, the research also covered the Cogs’ interplay with the project brief and first design critique conversation. The discussion that follows presents key research findings according to the subsidiary research questions.

#### **5.2.1. What was the influence of the Cogs on student outcomes?**

Overall the Cogs did not negatively affect the summative student outcomes captured in the Studio work marks. However, the scaffolding was of benefit to the novice students, whereas students with more design expertise actually fared slightly poorer than usual. These findings are similar to those of Arjun and Plume (2011), whose conversational tool was found to have more potential for supporting design thinking of novice than for expert designers.

One explanation for this determined ‘equalising’ effect could be that for the novice students the Cogs disentangled the design problem, provided a structured process and sequence, prompted problem finding and presented solution precedents. This allowed them to develop a design that met minimum functional requirements at least. According to Reiser (2004) this is precisely one of the features of a scaffolding tool; simplifying a complex problem.

For the more expert design students the Cogs did exactly the same, but the Cogs potentially scaffolded less sophisticated ‘ways’ of design thinking than what they might have acquired over time. This may have influenced the decrease in the quality of the more expert students’ designs compared to what they might have delivered if left to their own devices. Dorst and Reymen observed a similar outcome and referred to this negative influence of instructional support on more competent students as the “expertise reversal effect” (2004, p.8). This insight has ramifications for the use of compulsory scaffolding tools in the design studio where students have diverse ZPD needs (Vygotsky & Cole, 1978).

### **5.2.2. What did the Cogs contribute in scaffolding of Firmness as a guiding principle of architectural design?**

Firmness, as observed through the subtheme Materiality, was over-scaffolded by the Cogs. Evidence shows that students engaged with too many Materiality details too early on in their design process. This led to instances of rash or poorly reasoned material choices. This finding is similar to what Bell and Davis (2000) observed about student engagement with their scaffolding software, namely more general scaffolding, rather than too much detail, allow students to gain a more synthesized understanding of a task. By providing too much Materiality detail in the Cogs, students were not able to construct a balanced conceptual approach to Firmness.

### **5.2.3. What did the Cogs contribute in scaffolding Commodity as a guiding principle of architectural design?**

The Cogs' scaffolding of the principle of Commodity as observed through Functionality, was found to be the most effective of the three scaffolded Vitruvian principles. In terms of Functionality, the Cogs provided timeous and sufficient scaffolding. Students were able to respond to the prompts without having an initial concept. Smaller issues were observed by a minority of the sample student group, such as too much detail and that the Cogs were not presenting Functionality requirements relating to Wupperthal. On the whole students and tutors were satisfied with the Cogs' contribution to Commodity aspects of the pop-up shop designs.

### **5.2.4. What did the Cogs contribute in scaffolding Delight as a guiding principle of architectural design?**

Delight as observed through Form as a subtheme was under-scaffolded by the Cogs. The tutors interpreted the prevalence of box-shaped student designs as a lack of creativity and the fundamental flaw in this project. The three possible reasons evidenced for this prevalence were: 1) a perceived limiting size restriction provided in the project brief, 2) the pervasiveness of box-shaped precedents, and 3) conventional labeling of the target design object ('pop-up shop'). As it turned out, the limiting size restriction was misinterpreted by all project participants. In terms of the occurrence of the box-shaped precedents, the Cogs emulated the two box-shaped design examples presented in the project brief by providing five more. The design examples were also not suited to the project. Students' visualisation of the target design object was therefore influenced by an observed pattern. Finally, the appellation assigned to the design object ('pop-up shop') could have further restricted the manner in which students imagined their design or researched for precedents. Turkienicz and Westphal (2012) also found that assigning certain labels to design objects, in project briefs specifically,

limit students creatively. Although tutors took remedial action in the form of showing non-boxlike visuals post-critique, students could have absorbed these precedents in a similar superficial manner as they did with the initial set of visuals captured in the Cogs and design brief. Casakin (2004) found that novice designers are bound to make superficial comparisons between precedents and their design ideas, an issue that should be addressed as part of scaffolding, rather than just curating precedents for students.

In summary, the contribution of the Cogs in support of the Vitruvian guiding principles of architecture in this project was more explicit in terms of practical aspects. The creative aspects were left to be implicitly scaffolded by tutors. Turkienicz and Westphal (2012), Oxman (1999) and Williams and Askland (2012) all made the observation that issues of creativity are rarely explicated in design studio practices. Employing the Cogs to scaffold only the practical aspects of Firmness and Commodity and leaving Delight to be covered in the design critiques, was the intended strategy, but it led to an imbalance where Firmness was over-scaffolded and Delight under-scaffolded.

#### **5.2.5. What role did the Cogs play in students' formulation of the design intent?**

The first design critique was a formative opportunity for students to convey their design intent. The Cogs were used as a tool to scaffold students' formulation process prior to the critique. Students rated their design critique very favourably. Qualitative findings, however, revealed that students mostly credited their satisfaction to tutor feedback rather than with their own presentations. No clear connection could therefore be established between the Cogs and students' performance in the design critique.

In terms of the Cogs role in students' preparation for the design critique, students attributed most of their preparation to the role of the Cogs; two thirds stating that the Cogs played a "huge role" in their critique preparation. Tutors perceived students to be well prepared when

they arrived for their design critiques. Design critiques transcripts and tutor interviews, however, revealed that student designs were functionally satisfactory, but lacked creativity. This leads to the conclusion that the Cogs prepared students well for the functional and practical aspects of the design intent conversation, but not in terms of creative aspects. It is as Turkienicz and Westphal (2012) said: studio expectations regarding functional aspects are very clear, but creative expectations are not.

Vagueness around the definition of especially 'design intent' is another contributing factor. It was not covered in the Cogs (or project brief), and it is unlikely that students knew exactly what a design intent comprised, which would have complicated their being able to formulate one. Williams (2014) wrote that often these "threshold concepts" (p.12) are not very clear in the studio and sadly understanding what they mean is the key to unlocking the way of thinking that they require.

A further finding that hindered design intent formulation was that two flaws (size restriction and design perspective) in the interpretation of the project brief were uncovered. Clear project brief definition forms the foundation for a designer to respond to the set design requirements (Porter, 2004). This also revealed a misalignment between the project brief and Cogs, and project brief and design critique.

The unbalanced scaffolding of the Firmness, Commodity and Delight, particularly the under-scaffolding of Delight, skewed students' design intent to focus mostly on the more practical corners of Firmness and Commodity. Reiser (2004) was adamant that for a scaffolding tool to be effective it needs to represent the entire learning environment and message and not just selected aspects as was the case here.

Finally the Cog scaffolding did not facilitate the effective integration of Firmness, Commodity and Delight as the coherent whole that Vitruvius intended because Delight was



mostly absent. The Cogs were employed to cover separate themes and mostly offered domain content in the form of information and precedents in a siloed manner. Students were not scaffolded with the heuristic strategies on how integrate the different principles of Firmness, Commodity and Delight. And until there is balance between the corners of the triad it's not "meaningful architecture if architecture at all" (Heylighen & Neuckermans, 1999, p. 216).

### **5.3.Limitations of the study**

This research has achieved what it set out to do, but there were some unavoidable limitations. Firstly, I am not an architect or architecture educator. Although the lack of enculturation could mean a slightly more neutral interpretation, it could also mean a level of naivety regarding complex design and design studio practices.

While there is sufficient research precedent on the use of scaffolding tools, a second limitation is that the study of such tools using CA in a design context is still quite novel, with few examples upon which to base this study. In addition to that, I could not locate a study that uses the Vitruvian triad to codify pedagogical practices in architecture education.

The limiting scale of the research project allowed for only a small participant sample, which means that the findings are not fully generalisable. The research into students' conceptual design was also conducted on events of the first two days only of an already condensed studio project. In reality, lines between the different phases in the design process are blurred and locating the research in the first two days only is a crude demarcation of the conceptual design phase.

I attempted research in a fairly uncharted area, unsure of which data I would need and consequently collected a rather expansive set of data. The analysis process yielded a vast

body of findings comparable to what a condensed study such as this can bear so I could only present selected findings. Due to the interrelatedness of themes and subthemes, presenting a mere selection in the form of Materiality, Functionality and Form to present the entire Vitruvian triad means that I might have excluded insights that could have shed more light on important aspects of this event.

#### **5.4. Conclusion**

The purpose of the study was not to solve, but to explore. Cognician Cogs show great potential as a tool for scaffolding the student designer in process. In this instance architectural Delight was omitted which restricted students ability to produce novel designs. The fact that there were failings in this project provides opportunities for iteration. It also shed light on flawed studio practices, such the implicitness of creativity and the misalignment of the various scaffolds that might have gone unnoticed. Based on the findings of this study the ways under which Cognician Cogs could support conceptual design is to explicitly scaffold the creative, but not disconnected from other design requirements. It could also scaffold the ways of thinking that students need to integrate the Vitruvian triad. This will require the fine balance between using the tool to structure complexity for less-prepared students and to problematise the space for more expertly students as to best serve the diverse ZPD needs. The circumstances under which Cognician Cogs could support conceptual design pertain mostly to their alignment with other elements in the architecture studio such as the project brief and design critique. All tutors should also be briefed and content should be developed based on the required outcomes for the project. Once the scaffolds in the studio align, the scaffolding tool will be better positioned to help increase the design studio tutor's capacity.

## **5.5. Recommendations**

### **5.5.1. Policy and practice**

To ensure that all aspects of the learning environment work in concert, the curriculum for a studio project should ideally be designed in its entirety when new tools are introduced.

Incorporating explicit tools for creative assessment (for example, a rubric) could provide clarity in terms of design studio expectations amongst tutors and between students and tutors. This might also create a stronger alignment between the different scaffolds: the project brief scaffolding tool and the design critique.

Making abstract terminology explicit should be part of the pedagogical strategy, even if it is only to create a shared understanding for terms in a specific project. Tutors should also prompt students to articulate their understanding of certain terms.

Design expertise is heavily dependent on heuristic strategies, especially around issues of creativity and novelty, and should be the aim of any design curriculum. The incorporation of pedagogical support tools to scaffold studio learning conversations, assessment guidelines like rubrics or overt instructional models like cognitive apprenticeship, could create a starting point for design educators to reflect on and articulate their own heuristic strategies.

### **5.5.2. Further development in use of the tool**

In the development of content for a scaffolding tool, the underlying assumptions, privileged aspects, and implicit expectations and priorities that exist in the design studio will have to be taken into account by whoever is developing the content.

If the tool is to be used in a similar context again, the focus should be to develop content around design heuristics rather than architectural domain content per se. For instance, rather

than providing precedents in a bounded system, the Cogs could be used to scaffold students to search for and analyse their own precedents.

### **5.5.3. Further research**

Future research should focus on the use of scaffolding tools to support aspects of creativity, innovation and novelty in the design studio project.

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## Appendix A: Interview questions Students

### 1. Background

1.1 Student information: name, age, gender, working or studying full-time

1.2 How you use technology tools in your designing?

1.3 How far from ready-to-take-to-the-critique was your design by the time you started using the Cognician cogs on day 1 and day 2?

### 2. Use of Cognician Cog 1 before the Design Critique

**Cog 1:** Preparation for the Design Critique

Will provide just-in-time content and question prompts to scaffold reflection **on design precedents and design informants related to context, function and technology.**

Will also aim to elicit how students propose to articulate their design decisions and rationale during the design critique.

2.1 We will get to talking about the Cognician cogs you used... First, **what was your experience using a tablet in the studio as part of your design project?**

2.2 Cognician cogs were introduced as a technology tool as part of the studio project you are working on. **What happened to your design when you used the first cog? What happened to your design decisions when you used the first cog?**

2.3 **Can you give me an example of something you changed in your design while using the first cog?**

What triggered you to make this change?

Would you say that using the cog made you make more, the same or less changes to your design at that stage than in a studio project that you worked on without Cognician?

2.4 **I want to understand how you experienced the cog's question prompts relating to your design?**

2.5 **Did the introduction of information on precedents (food truck design examples) on the sidebar of the cog at that time motivate you to make changes? Why?/ Why not?**

2.6 **What about when the cog provided information on the context, the function and the technology that you need to consider for your design? What happened to your design?**

2.5 Think back to the one-on-one design critiques you have been through in the past. **In general how do you experience design critiques?**

2.5 **How did you feel about the design you took into the design critique?**

**2.6 What did using the cog do for the design product you took into the design critique?**

2.7 As a designer you were using different ways of communicating today. You were communicating your design (sketching or drawing it) and when you got to the design critique you would show it, but you would then also use words to verbally explain your design when you are discussing it with your lecturer. **How do you feel about the way in which you communicated your design verbally in today's design critique?**

2.8 We spoke about the different ways in which you as a designer communicated today, with your graphical design, with your words verbally when you had a conversation with your lecturer about your design. Using the cogs today also required you to type out, write down things about your design. **What was the experience like for you to type out your design thinking (the conversation you were having with yourself in your head about your design)?**

2.9 **Did typing out your design thinking beforehand change anything for you during the design critique?** How do you rate the value of typing out your design thinking?

### **3. The Use of Cog 2 after the Design critique**

**Cog 2: Reflection on the Design Critique**

Will provide just-in-time content and question prompts to scaffold **reflection on the completed design critique and feedback received from peers and tutor (lecturer).**

Will also aim to elicit students' perception on how well they articulated their design decisions in the design critique.

The same research questions posed to selected group for interviews will be included in cog 2 to triangulate interview data.

3.1 The second cog you used was after the design critique. **How did this cog influence your thoughts on the feedback you received from your lecturer and peers during the crit earlier?**

3.2 **What happened to your design after your critique?** And did this happen because of the critique or because you were doing cog 2?

3.3 Were you making more, less or the same amount of changes that you would make at another time after the critique?

3.4 **What was your experience typing out feedback on your crit after the crit?**

3.5 **What did you learn from the second cog? What effect will this have on how you prepare for future critiques?**

### **4. Input**

4.1 **If you could, would you like to use a tool like the Cognician again in your designing?**

4.2 You are a design student and therefore quite creative and you will have lots of ideas. So I would like your input as an architecture student who used Cognician in your studio project. **If you could give any advice to the developers who created Cognician cogs, what would that be?**

4.3 And can I ask your input on the content in the cogs. **What other content and information would you have liked to cog to provide to you at the stages when you used the cogs?**

4.4 **Thank you for your time and input. Is there anything else you would like to add before we end?**



# Lecturers

## 1. Background

1.1 Lecturer information: Name, duration teaching on this course

## 2. Design Critique

2.1 If you could think back to the one-on-one face-to-face design critiques you have conducted with students at this level in the past. **What frustrations have you experienced during those interactions?**

2.2 **To what would you contribute those things that led to your frustration?**

2.3 **How would you describe the designs that were presented to you yesterday?**

2.4 **How would you describe students ability to articulate' their design reasoning (talk about their design process) at design critiques in the past?**

2.5 **What did you notice about student's ability to talk about their designs yesterday?**

## 3. Reflection-in-action

**Cog 1:** Preparation for the Design Critique

Will provide just-in-time content and question prompts to scaffold reflection **on design precedents and design informants related to context, function and technology.**

Will also aim to elicit how students propose to articulate their design decisions and rationale during the design critique.

3.1 **How would you rate students' incorporation of precedents into their design?**

3.2 **How would you rate students' consideration of design informants (context, function and technology)?**

3.3 **From what you have seen, was there any difference to students' incorporation of precedents today compared to similar situations in the past? Can you explain that?**

3.4 **From what you have seen, was there any difference in how students considered design informants today compared to similar situations in the past? Can you explain that?**

3.5 **How would you rate the level of students' incorporation of basic procedural knowledge in their designs today?**

3.6 **I am trying to understand the quality of reflection that students engaged in while they were designing. What are your thoughts on this? Can you give me an example why you say that?**

#### **4. Reflection-on-action**

**4.1 How do you rate students' level of preparedness coming into the design critique yesterday?**

**4.2 Based on the designs you saw during the design critique, do you think students went through more, the same or less iterations (changes) during their design process? Why do you say this?**

**4.3 Is there anything that students could have done to be better prepared in the design critique?**

#### **5. Articulation**

**5.1 What are your thoughts on the quality of the conversations you had with students during their design critiques yesterday?**

**5.2 How would you rate students' use of design vocabulary in the design critique yesterday?**

**5.3 How would you rate student's confidence levels in talking about their designs yesterday?**

**5.4 What did you notice about students design reasoning yesterday?**

#### **6. Input**

**6.1 Where there any information lacking in what students' reasoning that you think should have been added to the intervention? What?**

**6.2 Thank you for your time and input. Is there anything else you would like to add before we end?**

## Appendix B Data processing detail

Table 3.1 *Data Processing Details*

Instrument	Original file format	Supplied by	Consists of	Processing Method	Processed to:	Processed by:	Quantity
Design Brief	Word	Tutor A	Text  Images	Line numbers	Word Document with numbered lines	LH	Words: 2180, Lines: 226, Images: 3
Observational Notes	iPad Notes	LH	Text	Type up in Word insert line numbers	Word Document with numbered lines	LH	Words: 899, Lines: 99
COGS 1-5: Content, Questions and Sidebar Information	Word	Cognician	Text	Copy into Word, Re-format and insert line numbers	Word Document with numbered lines	LH	Function Cog: Words: 624, Lines: 87, Images:1, Videos: 2  Ergonomics Cog: Words: 714, Lines: 95, Images: 2, Videos: 1  Activity Cog: Words: 811, Lines:93, Images: 2, Videos: 1  Materials Cog: Words:600, Lines: 92, Images: 1, Videos: 2  Construction Cog: Words: 685, Lines: 83, Images: 0, Videos: 2  Total: Words: 3434, Lines: 450, Images: 6, Videos: 8
Design Critique	Audio Recording  MP4 file  made with mobile phone	LH	Audio	Transcription: Audio to Text	Transcribed Word Document with numbered lines	Top Transcripts	Student 1 Critiqued by Tutor B  Words: 657, Lines: 52  Student 2 Critiqued by Tutor A  Words: 1526, Lines: 133  Student 3 Critiqued by Tutor D  Words: 663, Lines: 62

							(Recording cut off)  Student 4 Critiqued by Tutor A  Words: 1665, Lines: 138  Student 5 Critiqued by Tutor C  Words: 1517, Lines: 126  Student 6 Critiqued by Tutor C  Words: 1621, Lines: 151  Student 7 Critiqued by Tutor C  Words: 1413, Lines: 138  Student 8 Critiqued by Tutor D  Words: 4658, Lines: 481  Student 9 Critiqued by Tutor D  Words: 953, Lines: 86  Total: Words: 14 673 Lines: 1367
Crit Reflection Responses	Excel	Cognician	Numerical and text Responses	Cleaned up files and created line graphs	Line graphs	LH	
Interviews Student Sample	MP4 Audio	LH	Audio	Transcription: Audio to Text	Transcribed Word Document with numbered lines	Top Transcripts	Student 1: Words: 2576, Lines: 245  Student 2: Words: 5434, Lines: 579  Student 3: Words: 1813, Lines: 167  Student 4: Words: 5142, Lines: 517  Student 5: Words: 2594, Lines: 235  Student 6: Words: 3203,

							<p>Lines: 328</p> <p>Student 7: Words: 2360, Lines: 202</p> <p>Student 8: Words: 2484, Lines: 234</p> <p>Student 9: Words: 3338, Lines: 364</p> <p>Total: Words: 28944, Lines: 2871</p>
Interviews Tutors	<p>Audio Recording</p> <p>MP4 file</p> <p>made with mobile phone</p>	LH	Audio	Transcription: Audioto Text	Transcribed Word Document with numbered lines	Top Transcripts	<p>Tutor A: Words: 1539, Lines: 114</p> <p>Tutor B: Words: 2252, Lines: 198</p> <p>Tutor C: Words: 2281, Lines: 177</p> <p>Total: Words: 6072, Lines: 489</p>
Student Marks STW Project	Excel	Tutor A	Table	Cleaned up files and created line graph in Excel	Jpeg file of a graph	LH	

## Appendix C Ethical Permissions and Consent forms

From: Mastin Prinsloo  
Sent: 28 August 2013 07:25 AM  
To: Cheryl Hodgkinson-Williams  
Subject: RE: Liza's Proposal and attachments

Dear Cheryl,

Liza Hitge's research proposal has been approved by the School of Education's Research Ethics Committee as regards research involving human participants. As supervisor you will assist the research student with any ethical concerns that might arise in the course of the research. You are very welcome to consult the School of Education's Research Ethics Committee through me should anything arise on which you require advice or assistance.

If there is anything further to be done as regards signing off on ethical clearance for this research proposal please let me know.

Regards,  
Mastin

Mastin Prinsloo  
Associate Professor  
School of Education  
University of Cape Town

Chair: School of Education Research Ethics Committee

----- Forwarded message -----

From: **Anthony Staak** <[staaka@cput.ac.za](mailto:staaka@cput.ac.za)>  
Date: 30 August 2013 16:01  
Subject: Re: Fwd: Urgent Appeal for Research Permission at CPUT  
To: "<Liza Hitge" <[lizahitge@gmail.com](mailto:lizahitge@gmail.com)>  
Cc: [lizahitge@gmail.com](mailto:lizahitge@gmail.com)

Dear Liza  
Fyi  
Best wishes with your research.  
Regards

(Prof) A.P.Staak  
Deputy Vice-Chancellor: Academic  
Cape Peninsula University of Technology

Tel: [+27 21 4603356](tel:+27214603356)  
Fax: [+27 21 4603983](tel:+27214603983)

>>> Penelope ENGEL-HILLS 2013/08/30 02:58 PM >>>

Dear Johannes and Prof Staak,  
I am not familiar with reciprocity agreements and would like evidence of this if they exist for your faculty. UCT always still processes through their own channels for ethics review even when CPUT has given approval and we do the same. However they are very helpful and do expedited reviews wherever possible. We should continue to not automatically accept UCT (or any other institutions) ethics approval.

However to meet the demands of this urgent application I am willing to accept that the faculty in this case accepts UCT ethics approval. I will note that this proposal was not reviewed at CPUT but research was permitted by the faculty.  
You should convey this to the researcher.  
Regards, Penelope

>>> Johannes Cronje 2013/08/30 02:04 PM >>>

Dear Penny  
It went through UCT ethics review and the sent Prof Staak all the details.  
It has been my experience that there is reciprocity between institutions and thus we can accept the UCT ethics clearance.  
Best wishes  
Johannes

Consent form (Sample student group)

I, \_\_\_\_\_ hereby confirm that I have given Liza Hitge permission to:

- 1) Conduct an interview with me and make an audio recording of the interview,
- 2) Make an audio recording the first design critique session that will be conducted with me by my lecturer during the block week 2-6 September 2013;
- 3) Read and use the data from the completed scripts of my interactions with Cognician software (cog 1 and cog 2).

I understand that the interview, audio recording of my design critique session and Cognician scripts of will be used in the writing of her master's thesis. I am aware that she is a student in educational technology at the University of Cape Town (UCT) and that her research focuses on my experience using Cognician software as part of my September 2013 studio project.

I understand the interview will be a discussion of my thoughts, beliefs, experiences and design practices using Cognician software.

I will be given the opportunity to read the transcripts of the design critique and the interview to make sure that it accurately reflects what I said.

I am aware that my name will be altered to protect my identity in the written document.

I know that my participation is voluntary and unpaid. I also know that I can withdraw from participating in the research at any time.

Signed: \_\_\_\_\_ Date: \_\_\_\_\_

Email Address: (for receiving transcripts)

\_\_\_\_\_



Consent form (Whole student group)

I, \_\_\_\_\_ hereby confirm that I have given Liza Hitge permission to and use the completed scripts of my interactions with Cognician software (cog 1 and cog 2).

I understand that the Cognician scripts will be used in the writing of her master's thesis. I am aware that she is a student in educational technology at the University of Cape Town (UCT) and that her research focuses on my experience using Cognician software as part of my September 2013 studio project.

I am aware that my name will be altered to protect my identity in the written document.

I know that my participation is voluntary and unpaid. I also know that I can withdraw from participating in the research at any time.

Signed: \_\_\_\_\_ Date: \_\_\_\_\_

## Consent form (Tutors)

I, \_\_\_\_\_ hereby confirm that I have given Liza Hitge permission to:

- 1) Conduct an interview with me and make an audio recording of the interview,
- 2) Make an audio recording of the first design critique session that I will be conducting with students during the block week 2-6 September 2013;

I understand that the interviews and recorded design critiques will be used in the writing of her master's thesis. I am aware that she is a student in educational technology at the University of Cape Town (UCT) and that her research focuses on my students' use of Cognician software during their September 2013 studio project.

I understand the interview will be a discussion of my thoughts, beliefs, experiences and opinions about my students' design practice and reasoning as result of using Cognician software.

I will be given the opportunity to read the transcripts of the design critique and the interview to make sure that it accurately reflects what I said.

I

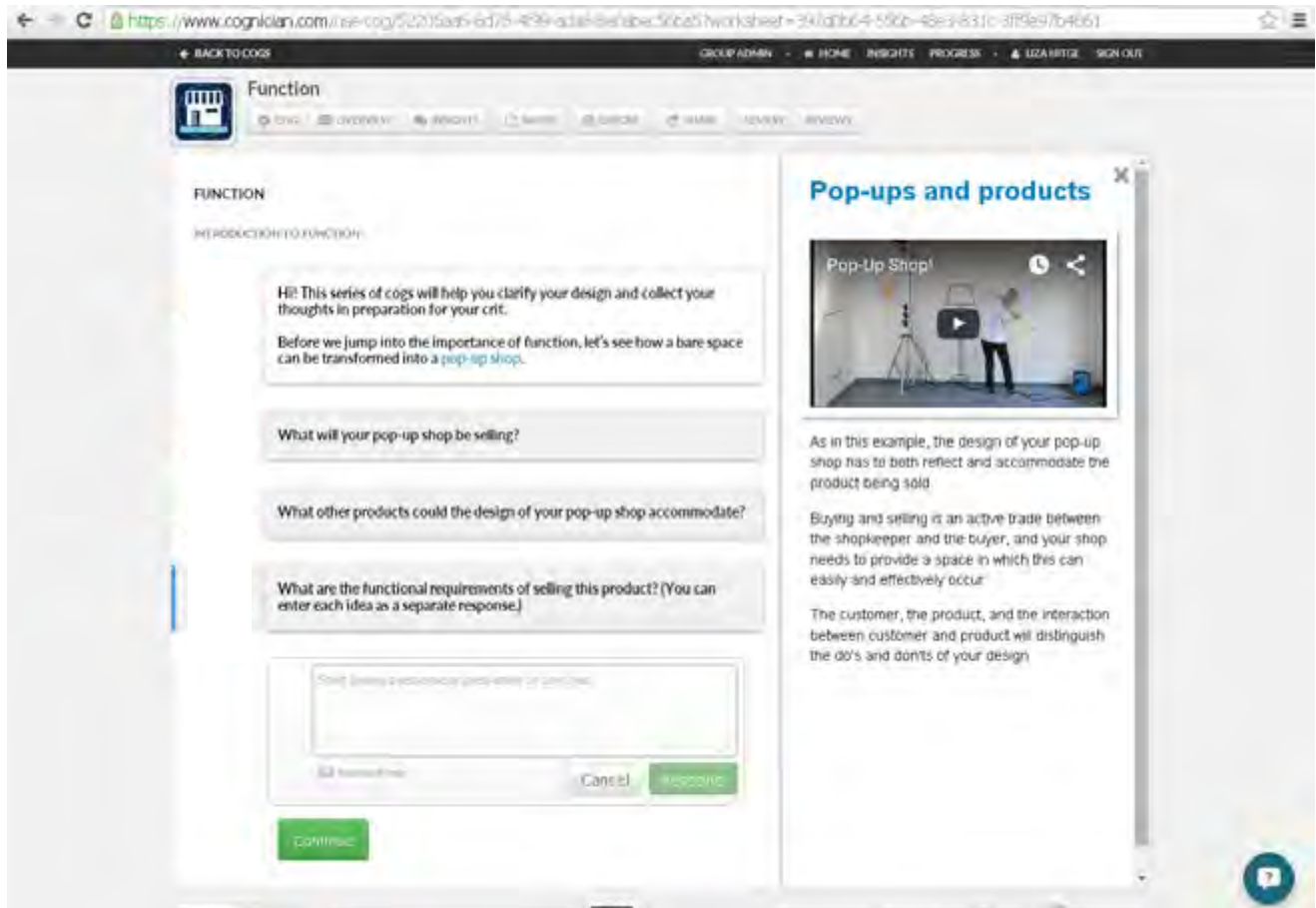
am aware that my name will be altered to protect my identity in the written document.

I know that my participation is voluntary and unpaid. I also know that I can withdraw from participating in the research at any time.

Signed: \_\_\_\_\_ Date: \_\_\_\_\_  
Email Address: (for receiving transcripts)

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## Appendix D Sample Script Function Cog Conversation



### Function

#### Introduction to function

Hi! This series of cogs will help you clarify your design and collect your thoughts in preparation for your crit.

Before we jump into the importance of function, let's see how a bare space can be transformed into a pop-up shop.

What will your pop-up shop be selling?

My pop up shop will be selling something that is readily available, creative, simple and of course, sustainable. For instance, I would like to implement gardening, arts and crafts or educational elements in to the pop-up shop.

What other products could the design of your pop-up shop accommodate?

Instead of thinking of products, one could rather associate products to services and education, then the products come.

What are the functional requirements of selling this product? (You can enter each idea as a separate response.)

Light- Plants cant grow properly without sufficient light, therefore it needs to be accommodated for.

Water- Plants require sufficient water in order to grow. This poses a bit of a problem, as water is the last thing you actually want in the building.

Air- Plants also require a sufficient amount of air and with no proper ventilation the above mentioned could create unpleasant environments to work in.

Circulation- Moving through the space comfortably is very important for the users.

Aesthetics- The most important think to most people, is how something looks. I f it does not look good and inviting, it will not be considered and accepted very easily.

Storage- This plays one of the biggest roles in the design. One needs a secure place to store goods. Without a secure place to store goods there can be no implementation of the arts and crafts, as the resources and tools are not at hand and readily available.

### **Reflection on function**

Architecture is about making the most of what you have so you can create designs that are innovative and functional.

What are the other functional requirements of your pop-up shop? You can enter each requirement as a separate response.

Refuse- There needs to be an area allocated for proper refuse disposal. This keeps the hygiene and aesthetics well balanced.

Comfort- Not just physically comfortable, but mentally and sub-consciously aswel

And in your design, how do you plan to meet each of these requirements?

The way in which i plan to meet these requirements is by understanding exactly what the pop-ups fuction is and determine how I will accomodate for it.

Are there any other functional requirements that you can think of?

Not at this moment..

### **Preparation for your crit**

Now that you have an idea of how your design needs to function, you, yourself need to know how to function in your crit.

When you're asked about function during your crit, what ideas about your design would you like to highlight?

Why I did what i did and what influenced it all.

And what can you do to prepare yourself to confidently discuss these ideas?

make sure that i my self understand my intentions and have sufficient information to assist in the way i present my ideas.

## **Share and Finish**

### **Share**

Congrats! You've gotten to the end of your first cog! Before we end off, let's share what we've learnt.

By going through this cog, what have you realised about the role functionality plays in design that you would like to share with your peers?

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Functionality is an over used term that has on simple meaning. 'Who, what, where and how is it used'...

### **Finish**

We'll see each other in the next cog on ergonomics, but before we do, take some time to digest what you've just learnt. Bye for now!

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