

Design Conversations

An exploratory study of teacher and student interaction in the design studio

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Design

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design

studio

João

Ferreira

Design Conversations – An exploratory study of teacher and student
interaction in the design studio

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van der Hagen

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by

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Design Conversations

An exploratory study
of teacher and student
interaction in the design
studio.

João Ferreira

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Notes on typographical conventions and writing style

Spelling

This thesis is written following the British English language spelling conventions.

Citation

We use the American Psychological Association (APA) norms for referencing and citations.

Gender neutral pronom

There are no gender neutral pronouns in the English language. Until recently, most authors used the male pronouns “He, him” when referring to an unknown person as an example. While most recent style guides recommend that this should be avoided, at the moment, there are no established conventions concerning this matter, and the decision of which pronoun to use as the gender neutral falls upon the author.

Also, there have been attempts to introduce the plural “they, their” as a gender neutral pronoun, but we find this solution detrimental to the clarity of reading. Also, the alternatives “s/he” or “he/she” or “he or she” strain the reader’s experience.

Clarity and conciseness of the text should prevail. Therefore, for this thesis, when referring to an unknown person as an example, we will predominantly use the following convention: if we are referring to an unknown teacher we will use he/him, whereas in the case of a student we shall employ she/her (following Donald Schön’s case study of design education that includes a male teacher and a female student).

We will also try, whenever possible, to use the plural instead of the singular in the following manner:

Instead of saying: “A student often presents his sketches without much explanation.”

We may write: “Students often present their sketches without much explanation.”

However, this solution, while grammatically correct, is more vague and therefore will be used sparingly.

Use of ‘we’ and the passive voice

Even though this thesis is my own original work, I shall use ‘we’ (this paragraph being a rare exception) instead of the first person ‘I’. The alternative to the use of ‘we’ would be to repeatedly use the passive voice, which makes for difficult reading and is universally discouraged by style guides (both academic and literary).

Oxford comma

In this thesis, We will adopt the ‘oxford comma’ in enumerations. For example:

“Design, architecture, and fashion.”

instead of

“Design, architecture and fashion.”

To my wonderful wife Inês,
and to my baby boy Henrique.

In memoriam

Uncle Zé, uncle Carlos, grandfather Joaquim, and D^a Augusta.

Chapter 1

Introduction

1.1 Problem statement

1.1.1. Design Conversations: Teacher-student interaction in a design studio setting

This thesis explores the teacher–student interactions that take place in a design studio educational setting. We named these interactions ‘design conversations’ – a term that describes the instances of one-on-one dialogue between a teacher and a student while presenting, reviewing, or working on a design project.

Teacher–student dialogue is a defining feature of design education. In professional practice, designers do not talk about their working process while they design, designing is a silent activity externalised most often by drawings (Goldschmidt, 1991; Purcell & Gero, 1998) and other visual representations (Pei, Campbell, & Evans, 2011). This is evident from experimental research settings where researchers aim to analyse the design process as it occurs. For this to be possible, researchers must instruct the participant designers to think out loud as they design to produce data to be analysed as verbal protocols¹ (see Cross, Dorst, & Christiaans, [1996]). An exception is the case of working in teams, in this instance, designers must inevitably talk to each other as they work on a project (Medway & Andrews, 1992). However, conversations in a professional context are held between peers, as such, even considering the case of interactions between senior and junior designers, the interaction is not pedagogical in nature².

On the contrary, the dialogue that unfolds between teacher and student in a design studio setting is not only expected but a crucial aspect of the teaching/learning process. In the design studio, the teacher plays the role of the expert as he guides students during their attempts at designing, but this team of two designers is not constituted by equal participants. During these meetings, it is a part of the teacher’s role to explicitly talk about design (and about designing) which necessarily means that the teacher is required to explain his thoughts – and actions – verbally. Furthermore, it

1 Analysis of verbal protocols is recurrently used to analyse design activity (Lloyd, Lawson, & Scott, 1995) and has become a staple of design research.

2 Notice that we are not questioning the view that design is often a collaborative activity. There are numerous stakeholders involved in a design project (client, designer, users, manufacturers, suppliers and so on) and effective communication between all of them is crucial for a successful design project. However, it seems clear that there are differences between talking while designing (as is the case of a professional design meeting discussing specific aspects concerning a design project), talking about designing in the context of an educational setting (which presupposes one of the participants to assume a pedagogical role) and being asked to talk out loud about one’s design process while designing (the case of experimental settings).

is often the case in design education that the teacher complements these verbalisations with sketching and vice-versa. This focus on making the design process explicit through unprompted verbalisations (Oak, 2006) and visualisations is a distinctive feature of the teacher-student dialogue that unfolds in a design studio setting.

1.1.2 The language of design

A particular aspect of the teacher-student dialogue in the design studio is the language used. Donald Schön primarily based the development of his influential³ theory (Schön, 1983, 1985, 1987) of reflective practice⁴ on a close examination of the design studio educational setting. The author observed that design conversations were to a great extent conducted using a *language of designing*, according to Schön, this is a two-part language where verbal and visual expression are closely connected: “Drawing and talking are parallel ways of designing, and together make up what I will call the language of designing.” (Schön, 1983, p.101).

The author describes the language of designing as a language for doing design, a language game⁵ that the teacher models for the student. According to Schön, the language of designing is twofold: (1) on the one hand, it refers to *elements* of the language of designing. These elements can be grouped into clusters that constitute general design domains that fulfil a variety of constructive, descriptive, and normative functions (examples of design domains include, for instance: form, structure, materials, or precedents); and (2) the discourse is also focused on talk

-
- 3 Schön remains one of the most influential scholars in design research. Chai and Xiao (2012) analysed *Design Studies* journal articles between the years 1996 and 2010 and found Schön to be the most frequently cited scholar in that journal (the *Design Studies* Journal, published by Elsevier, is a publication dedicated to studying the process of design, and is the design research publication with the highest citation impact [Cross, 2009]), even though Beck and Chiapello (2016) observed that Schön's work is often cited without significant critical engagement with the author's ideas.
 - 4 Donald Schön (1983) used his research on the architecture educational studio to develop a general theory of practice for the professions, which he called *reflective practice*, partly as a reaction to Herbert Simon's book *The Sciences of the Artificial* (1996). These two conceptions of design are rooted in opposing epistemological perspectives. Simon's proposal – the rational problem-solving paradigm – is that designing could be addressed as a rational problem-solving activity; crucial to his conception is the notion that a design problem defines the 'problem space' and the solution can be obtained by exploring it. Therefore, the solution is determined by the problem. On the contrary, in Schön's reflective practice paradigm, the author does not assume that a design problem is definable beforehand. According to Schön, design should be regarded as a reflective conversation that focuses on the structuring role of the designer. The centre of this theory lies in the idea of 'reflection in action,' which proposes that the moments of reflection emerge from the ongoing dialogue with unexpected situations. In the reflective practice paradigm, there is no a priori way of determining the best possible approach for a design problem. The problem and possible solutions are framed together by the designer's actions.
 - 5 Schön draws the term “language-game” from Wittgenstein (1986), according to this author, words are inseparable from the actions in which they occurred: “I shall also call the whole, consisting of language and the actions into which it is woven, the 'language-game'” (p.5).

about designing, that is, a metalanguage that describes features of the design process itself and introduces the student to reflection on the action of designing.⁶

To what extent these two dimensions of the language of designing are expressed both verbally and visually is not clear from Schön's studies, has Marda (1996) observed, Schön did not intend to present a comprehensively structured model of the language of designing⁷: "Schön did not research the structure of the design language, nor its function in a learning environment. His presentation of the design language remains at a descriptive level." (p.17)

Nevertheless, the studies of studio interactions presented by Schön (1983) support the notion that design language is used as a common language during teacher-student dialogue in a design studio. While teacher and student may or may not sketch⁸ during design studio meetings, we can safely assume that every teacher and student interaction is in part – and often exclusively – a conversation.

Additionally, a fundamental part of design language is that it is contingent on the practice of designing, that is, the words spoken while designing gain their meanings in the operational context of the design project. When teacher or student refers to a particular design domain, for instance, they do so in connection with the specific context of a design project. This means that their significance cannot be established a priori. As Heylighen, Bouwen, and Neuckermans (1999) observed:

The importance of this communication through designing derives from the fact that part of design knowledge/knowing is embedded

-
- 6 These two categories of the language of designing parallel what researchers focussing on cognition (Eastman, Newstetter, & McCracken, 2001) describe as two types of design knowledge: (1) declarative knowledge which is domain-related and technical and might concern, for instance, ergonomic data, material characteristics, colour theory, and so on; and (2) procedural knowledge that deals with the process of designing itself. The first type of design knowledge is easier to identify, categorise, and communicate to students in textbooks and lectures, while the second type is more elusive, tacit, and communicated through tutoring in the studio. Other authors, such as Christiaans (1992) and Venselaar, Hoop, and Drunen (1987) describe the same categories as *domain-specific basic knowledge* and *domain-specific design knowledge*, to which the authors add domain-independent process knowledge, that is, strategic knowledge that can be applied independently across different human activities.
 - 7 The fact that Schön did not expand on the concept beyond identifying it and describing its components and purpose in the design studio, means that the author never abandoned the term 'language of designing' which is a term that can be confusing or make for difficult reading at times. Therefore, since we will develop the language of designing as an observational framework for design conversations, we will, henceforth, predominantly use the terms *design language* or *language of design*.
 - 8 While sketching may or may not occur during a design conversation, there will be drawings, models, or other visual elements present mediating the dialogue between teacher and student – we will expand on the role of visual representations as mediating artefacts of teacher-student dialogue in chapter 2.

within the design process. The student cannot be told the essential things at the outset because they are encapsulated within the very act of designing. (p.219)

The meaning emerges from what Schön describes as the operational moves the designer makes and the consequent material back-talk of the context.⁹ It is the role of the teacher to guide the student through this process by clarifying the connections between the actions (in the words of Schön the 'design moves') and the consequences for the design situation.

As such, the teacher can use design language to render the elusive design process more explicit for the student. So we gather that the role of the teacher is dual: on the one hand, the teacher is using the language to communicate with the student, that is, as a way of illustrating what he is demonstrating the teacher highlights aspects of the design process as it unfolds. On the other hand, the conversation also has the purpose of teaching the student the design language itself. Therefore, design conversations present a dialogue between a teacher that knows the language of design and a student that is still in the process of learning it to be able to efficiently communicate with the teacher.

This predicament is similar to learning a foreign language, but with the particular difficulty, in design conversations, that the student has access to a dictionary but no explicit grammar rules to string the words together into sentences.

While design domains can be described in books and lectures, and models of the design process are available, these are fundamentally descriptive and not prescriptive. The student cannot know what part of this knowledge is useful before engaging with the particular circumstances of any given design situation. Design is not discursively teachable; the learning of design practice is fundamentally an experience that unfolds by engaging with project work in a design studio. Design is less something to be taught but a skill to practice.

Therefore, we gather that students are asked to design and learn how to design at the same time (Sachs, 1999). This situation renders design conversations between tutor and pupil in the design studio as the crucial moments in which learning *how* to design occurs. Schön (1987) highlighted this situation and called this difficulty the paradox and predicament of learning to design, according to the author, the student:

⁹ The concept of design language is connected to Schön's conception of design activity as a dialogue with the materials of a situation. Crucial to the author's theory is the notion that designers use *frames* to temporarily establish order in the often messy and ill-defined design situations. The frame determines the necessary limits for experimentation and 'dialogue' with the materials of the situation.

[I]s expected to plunge into designing, trying from the very outset to do what he does not yet know how to do, in order to get the sort of experience that will help him learn what designing means. He cannot make an informed choice to take this plunge because he does not yet grasp its essential meanings, and his instructors cannot convey these to him until he has had the requisite experience. Thus, he must jump in without knowing – indeed, in order to discover – what he needs to learn. (p.93)

1.1.3 Design studio setting – the fundamental problems

The design studio setting is problematic for the everyday practice of teachers since the effectiveness of the teaching/learning process greatly depends on the personal interaction between teacher and student. Additionally, it is common that design studio teachers are also – or have been – practitioners who do not have specific pedagogical training (Dinham, 1989) which means that teachers are left to their own experience and common sense as guides for their teaching (Curry, 2014).

However, there are specific difficulties in design education that make it challenging to provide design teachers with precise pedagogical tools, or procedures, which could be applicable in their teaching practice. The consensus is that learning how to design must mainly take place in the design studio, as Lawson (2004) observed:

There seems to be a certain kind of knowledge and understanding that it is very hard to attain in any way other than by actually designing seriously. All those schools of design understand this too and use methods of learning by doing in the 'studio' format as their primary educational tool. (p.7)

Therefore, design schools are generally structured along two axes: (1) on the one hand, there theoretical lectures that focus on the relevant sub-disciplines (such as ergonomics, computer assisted design, drawing, design history, materials and technology, design theory, and so on), which are organised much like any university course, with a series of lectures and evaluation by means of formal exams; (2) on the other hand, there is the design studio, a setting that simulates a professional design experience in a controlled educational environment, it is, fundamentally, a space where students practice designing during projects while being tutored by a teacher.

Thus, the project experience in the design studio is the centre of a student's educational path (Salama, 1995; Green, 2005); throughout the years of the course, the design studio is the focal point around which the supporting sub-disciplines are arranged in order to supplement the teaching and learning that takes place in the studio; and while the

balance between design studio time and the other (lecture-based) courses varies between design disciplines, design project experience is generally regarded as the fundamental part of the design student's education (Mcdonnell, 2014).

This setting is typical of design disciplines such as architecture, product and industrial design, interior design, urban planning, or fashion design (Cennamo & Brandt, 2012; Goldschmidt, Hochman, & Dafni, 2010; Hokanson & Gibbons, 2014) and less frequent in engineering schools and software design courses, even though there have been efforts in trying to import the design studio as an educational setting to these disciplines (College, 2001; Kuhn & Lowell, 1998; Kellam, 2013; Vrcelj & Attard, 2007). Lawson (2004) observes that this type of teaching is a global pattern across countries and design disciplines:

(...) design education looks different to much else of what goes on in universities around the world. In fact you can go into schools of design and see a very similar pattern repeating time and again. This is true whether the school is in England, The Netherlands, the USA, Australia, Malaysia or Hong Kong. In fact it appears to be a pretty global pattern. It is true whether the school is teaching architecture, product design, interior design or landscape design. (p.6)

Moreover, this widely accepted basis for design education is often described as a form of 'learning by doing' (Ellmers, 2014; Goldschmidt et al., 2010; Green & Bonollo, 2003; Kurt, 2009; Schön, 1987; Utaberta, Hassanpour, Che Ani, & Surat, 2011; Wilson & Harris, 2003) an educational paradigm that stems from the tradition of the guilds in medieval Europe where the 'master-(journeyman)-apprentice' model was in use to educate craftsman (Sennett, 2008) from where it was adopted by the renaissance academies and finally established in the modern day universities as the preferred method to teach design (Barzman, 2000). Partly based on this model, the theory of constructivism was introduced in the twentieth century¹⁰.

This broad conception of learning-by-doing, however, is quite ambivalent

10 In its most general assumption Constructivism states that knowledge and meaning are generated by our experiences. Piaget (2001) developed the hypothesis that there are no innate cognitive structures. According to the author, these structures are constructed by the subject during his actions in the social medium. This view was shared by most constructivists, being essential the work of Lev Vygotsky (1986) whose social-constructivist theory placed greater focus on the importance of the social medium in the learning process. In this perspective, the Russian author argues that learning is a complex social process, that is, learning is not solely an individualistic endeavour but essentially a social activity. Learning turns on a set of internal processes that operate when students are interacting with colleagues or with the teacher. These processes, once internalised, become part of the evolutionary achievements of students. This social dimension of learning was also emphasised throughout John Dewey's (1998) work.

since it appears too generic to be concretely applied to design education in a meaningful way. The same can be argued of *project-based learning*¹¹ which is a field of study in its own right; and while the general framework of design education appears to be compatible with constructivist learning theory (Kocadere & Ozgen, 2012), the constructivist model of pedagogy can only describe the design educational setting in its most generic aspects, while leaving out the idiosyncrasies that are distinctive of the design discipline.

The design studio is then an educational setting where students fundamentally learn by practising under the supervision of a teacher. Since students learn how to design by practising designing, then the particularities of design practice have an impact on the teaching and learning process in the design studio. It is, therefore, necessary to understand what makes the practice of design unique and why it is appropriate to teach it in a studio model.

ILL-DEFINED PROBLEMS

Fundamental to learning how to design in the studio is the premise that design deals with problems that are ill-defined¹². Typical design problems resist rigid definitions and are better described as wicked problems (Buchanan, 1992). A design problem – being ill-defined, or *wicked* – has no definitive formulation; its solutions challenge a binary logic of being either true or false (which is quantifiable and objective) but are either better or worse (mainly qualitative and subjective); every design problem is unique, therefore, when designing, there is no single approach or repetitive procedure to be followed.

This poses a difficulty for teachers. Design is about solving open-ended challenges for specific situations; there are no algorithms or logical models that can be applied. Since there is no single approach that can be applied in design problem-solving, then design can be described as a situated activity (Gero & Kannengiesser, 2004), which means that each solution is unique and context-dependent. Designers resolve issues within the environment in which they design (Suwa, Gero, & Purcell, 2006), and there are no procedures that guarantee a perfect solution, only better or worse ones. Thus, the expectation is placed on teachers to guide students

11 Project-based learning is a form of situated learning based on the constructivist notion that students gain a deeper understanding of learning material when they actively construct meaning based on their experiences and interaction in the world (Krajcik & Blumenfeld, 2006). The roots of project-based learning are based mainly on the work of John Dewey (1998), who argued that students will develop a personal investment in the material if they engage in real problems that emulate real-world situations.

12 An ill-defined problem (sometimes referred as ill-structured) is a term proposed by Rittel and Webber (1973) to describe the type of problems that lack a precise definition and can occur in any domain that involves stakeholders with differing perspectives and objectives.

engage in an unpredictable process as they experience the ambiguity of a design project.

MODELS OF THE DESIGN PROCESS

While every design problem is considered unique and therefore so are the procedures to solve it, many authors have proposed models that map the design process from beginning to end. The earliest proposals can be traced to John Chris Jones's *Design Methods* (1992, first edition 1970) and Christopher Alexander's *Notes on the Synthesis of Form* (1964), while more recent efforts include Roozenburg and Eekels (1995) work, or Nigel Cross' (1993).

Most design methods share the notion that the design process consists of a sequence of distinct activities that take place in a predictable (and logical) order. Bryan Lawson presented an analysis and overview of models of the design process in his book *How Designers Think: The Design Process Demystified* (2005), where the author summarises the common activities as a sequence of four distinct phases: Briefing, Analysis, Synthesis, and Evaluation.

These activities can be summarised thusly: the *briefing* describes the problem and consists of the first encounter with the problem's constraints, limits, and objectives; *analysis* is the understanding, ordering, and structuring of the problem; *synthesis* is characterised by an attempt to move forward and create a suitable solution to the problem; and finally, *evaluation* is the appraisal and critical consideration of suggested solutions when compared with the initial objectives identified in the analysis phase.

This description of the design process appears entirely reasonable and even logical. However, the fragmentation of the design process from whole to distinct parts is inconsistent with what is known about design practice, and therefore is problematic as a potential teaching tool in the studio. For instance, the briefing, which should be the most consensual and easy to describe stage of the process, when considered in practice, suddenly becomes less clear, as Lawson (2004) observed the "briefing is now generally regarded as a continuous process rather than one which takes place exclusively at the start of the project." (p.13)

Additionally, while models of the design process vary, the notion that there is a stage of *analysis* that concerns the rational consideration and definition of a problem that precedes (and is separate) from a *synthesis* stage which concerns the creative endeavour of coming up with a solution is at odds with what is known about professional design activity from experienced designers. For instance, in a reflection about his design process, the designer Michael Bierut (2010) stated:

For twenty years, I've been writing proposals for projects. And almost every one of them has a passage somewhere that begins something like this: 'This project will be divided in four phases: Orientation and Analysis, Conceptual Design, Design Development, and Implementation.' (...) The other day I was looking at a proposal for a project I finished a few months ago. The result, by my measure and by the client's, was successful. But guess what? The process I so reassuringly put forward at the outset had almost nothing to do with the way the project actually went. (p.4)

The latter quote serves to illustrate the realisation that the few studies (for instance Cross [2004] and Lawson [1994]) that looked into how outstanding designers work, strongly suggest that the notion of a stable and linear design process with distinct stages is inconsistent with how designing unfolds in practice.

In a reflection about how design methods relate to expert practice Cross (2004) observes that methods are usually tested in laboratory settings either with students or with designers, but seldom tested in a real-context working situation. Lawson (2005, first edition 1980) makes a similar remark when he observes that most design methods are “both theoretical and prescriptive. They seem to have been derived more by thinking about design than by experimentally observing it, and characteristically they are logical and systematic” (p.40), the author later added that “once we take other evidence into account about the design processes of experienced and outstanding designers we shall see that some at least use quite different sequences” (2004, p.15)

The problematic issue with most design methods is the distinction between problem and solution, and their corresponding analysis and synthesis stages. When observed in the context of expert design work, the problem is shaped as the solution emerges and is tested, that is, problem and solution co-evolve. The co-evolution of problem and solution means that instead of attempting to define or understand the problem fully (the analysis phase) before making solution attempts (the synthesis phase) expert designers “move rapidly to early solution conjectures, and use these conjectures as a way of exploring and defining problem-and-solution together.” (Cross, 2004, p.431)

Furthermore, experienced designers often work with solution conjectures early in their process instead of starting with in-depth problem analysis, which means that designers tend to interpret design problems according to conjectural solutions (Lloyd & Scott, 1994).

This kind of problem setting by the designer is also one of the critical aspects of the reflective practice theory proposed by Schön (1983), where the author described the activity of problem setting as ‘framing’, which is

the process by which a designer sets the tentative boundaries, constraints, and objectives alongside with a possible solution for a problematic design situation, therefore establishing a momentary coherence that propels the process forward (Schön, 1988). The author also highlighted that this framing is ongoing, that is, it is not established only once at the start of the design process. Other authors (Goel & Pirolli, 1992; Lloyd & Scott, 1995) also observed that framing repeatedly occurred throughout the development of a design project.

Therefore, we gather that designers tend to use solution conjectures to develop their understanding of the design problem. In design practice, a problem cannot be fully understood separately from a consideration of a solution, and these solution conjectures are used to explore and understand the problem formulation (Kolodner & Wills, 1996). In short, the problem and solution co-evolve. This interpretation of design as a co-evolution of problem and solution has been proposed by other authors (Suwa et al., 2006), and has been observed by Dorst and Cross (2001) in studies of experienced industrial designers.

Furthermore, this understanding of designing as a process of problem and solution co-evolution has led to the widespread use of the term *design situation* in design research literature. Schön as described designing as a reflective conversation with the materials of a design situation (1992), the author further explains that a design situation is a material reality that is apprehended through active sensory appreciation. Schön reinforces that this is true “both when the designer is on site, and when he or she operates in the virtual world of a sketchpad, scale model or computer screen.” (p.4) Through this active sensory appreciation, the designers construct the objects and relationships that determine the design world in which they operate. In short, a design situation is a setting in which the problematic aspects and partial solutions are simultaneously constructed and explored as the project unfolds until a satisfactory problem-solution pair is achieved and sufficiently described.

Additionally, also running contradictory to the literature on design methodology is the observation that in professional practice, expert designers often deviate from a methodical and linear process in the pursuit of partial solutions that spontaneously grasp the designer’s curiosity (Visser, 1990). This opportunistic approach to design activity, as the designer pursues the issues and requirements that are relevant in a tentative problem and solution pair has also been observed in a more recent study by Daalhuizen (2014).

These results are inconsistent with models of the design process where the detailed specification of a problem precedes the development of a solution, and where the design solution is elaborated in a top-down

approach from lesser to greater detail. Since there is no linear path between problem and solution (problem and solution co-evolve), then the structuring role of the designer is key. The solution(s) to a design problem considerably depends on how the problem is framed, that is, the definition of the problem is not given a priori but is subject to the solution, or partial solutions, that are chosen or defined by the designer.

In summary, what these models explain is that designers must gather information about a problem, study and explore it, devise a solution, evaluate it, and draw it with sufficient detail to make its production possible. However, these activities do not happen necessarily in that order (or only once). Models of the design process are essentially descriptive¹³ of the most general aspects that are common in the practice of most design disciplines (Bucciarelli, Goldschmidt, & Schön, 1987).

As a conclusion to his studies on the design process, Lawson (2005) proposed a descriptive model where the process should be understood as a negotiation between problem and solution, where the activities of *analysis*, *synthesis*, and *evaluation* are involved but without an indication of neither a starting nor a finishing point, nor yet any establishment of direction of flow (such as return loops) from one activity to the other. The author further warns against the apparently logical progression between initial *outline proposals* to later *detail design*, because this sequence implies that designers work from the general to the specific and studies of professional designers have suggested that this is often not the case.

Therefore, we gather that there are no specific methodologies that accurately describe how designers design beyond the enumeration of the general activities of analysis-synthesis-evaluation that occur in repeated cycles but in no particular order. Thus, design is not a step-by-step process and following a prescribed methodology does not guarantee a successful design solution.

Furthermore, practising design along these lines is not an accurate simulation of professional design practice and can be detrimental to students. Lawson observed that “with the introduction of systematic design methods into design education it became fashionable to require students to prepare reports accompanying their designs” (2005, p. 34), the author noticed that this practice of gathering information prior to working on solutions led to the failure to integrate the information into

13 Roozenburg & Cross (1991) identified a prescriptive-descriptive divide in design methods literature; the authors proposed a separation between engineering models and architectural/industrial design models of the design process. The former is systematic, tends to describe problems as possible to define, begins with problem-analysis, and is prescriptive of design behaviour; the latter assumes design problems as ill-defined, is opportunistic, starts with solution-conjectures, is cyclical, and descriptive of design behaviour.

the design. Christiaans and Dorst (1992) made a similar observation, later adding that they noticed the students became stuck at information gathering: “gathering data was sometimes just a substitute activity for actually doing any design work” (Cross, Christiaans, & Dorst, 1994, p.43) while Atman, Chimka, Bursic, and Nachtmann (1999) also observed in their studies that novice industrial design students often became stuck in problem-definition.

Teaching students how to design does not consist of telling students to follow instructions on a map because that is not how designing unfolds. Teachers cannot tell students to *start from point A and follow these steps (B, C, D, and E, and so on), and you will have a design*. Even models that include iterative or cyclical loops between stages still fundamentally presuppose that the stages are distinct, and furthermore, as Lawson (2005) observed:

Knowing that design consists of analysis, synthesis and evaluation linked in an iterative cycle will no more enable you to design than knowing the movements of breaststroke will prevent you from sinking in a swimming pool. You will just have to put it all together for yourself. (pp.39-40)

The overall problem of the design studio educational setting (in short, *how to teach students how to design?*) therefore persists. Since designing cannot be taught didactically – as a set of instructions to follow – and there is no definitive design methodology to prescribe, then the onus is on the teacher to make the design process more clear and explicit for the student. However, designers typically find it difficult to explain how they design because designing is basically tacit knowledge.

TACIT KNOWLEDGE – THE KEY PROBLEM OF THE DESIGN STUDIO EDUCATIONAL SETTING

In the design studio setting the teacher is required to articulate his expertise to the students. However, a fundamental difficulty of this setting is that there is often a gap between what a teacher knows about designing and what he can articulate for the student. This is so because the design teacher’s knowledge about designing is mostly tacit knowledge.

The concept of tacit knowledge as developed by Polanyi (2009) can be an adequate way to describe knowledge about designing. Tacit knowledge is understood as implicit knowledge that is not easily shared with another person. According to Polanyi, tacit knowledge describes knowledge that people are not aware they possess or how it can be useful to others. Additionally, tacit knowledge often leads to spontaneous actions and judgements and, in most cases, we cannot accurately describe or identify the knowledge behind those actions. For instance, Polanyi argues there are specific tacit components of human knowledge that enable people

to ride a bicycle, or play a musical instrument without being able to articulate precisely how they accomplish these tasks; thus, while people are aware they can accomplish it (ride a bicycle or swim) this awareness is not sufficient to articulate *how* they do it.

Polanyi draws on Gilbert Ryle's (1945) understanding of the ideas of 'knowing that' and 'knowing how'. Ryle argued against the view that states that intelligence (the 'knowing that') is distinct from the practical application of intelligence (the 'knowing how'.) According to this view – which Ryle opposes – intelligence does not directly influence actions and is expressed in propositions such as: 'I *know that* the Earth orbits the Sun'. On the other hand, practice is not expressed in propositions but rather in some form of action: such as riding a bicycle (which is something we *know how* to do). Ryle opposed this separation of intelligence and performance, according to the author, there is no gap between intelligence and actions, performance implies an intelligent act and therefore does not require the mediation of contemplative propositions. Building on this notion, Polanyi states that “these two aspects of knowing have a similar structure and neither is ever present without the other. (...) I shall always speak of 'knowing'; therefore, to cover both practical and theoretical knowledge.” (pp.6-7)¹⁴

This combination of thinking and doing – of theory and practice – is particularly helpful to understand design. Schön (1987) argued that knowledge about designing is a sort of knowing-in-action; the author states that designing is a kind of *artistry* that develops over time spent doing professional design work. This artistry can be summarised as the capacity for intuitive and spontaneous performance when faced with a design problem. This description is consistent with the 'ill-behaved' designer described by Cross (2004), from whose studies we gather that expert designers often follow opportunistic lines of exploration, partial solutions, or solution details on apparent whims, without much concern for stable methodological approaches.

Richard Sennett's concept of *craftsmanship* was developed along comparable lines to Schön's *artistry*. Similarly to Schön, Sennett (2008) also concentrated on the professions as a whole and stated that all human activity involves a sort of craftsmanship that the author defines as “the desire to do a job well for its own sake” (p.9). According to Sennett,

14 While both Ryle and Polanyi present a good case supporting the idea that practice is an intelligent act (often related to tacit knowledge) it does not necessarily follow that there is only one form of intelligence. Discussion of this topic is well beyond the scope of this thesis. Nevertheless, it seems clear to us that Polanyi's notion of tacit knowledge supports the understanding that design practice entails – in itself – an intelligent act (even if it might often be described as spontaneous or intuitive, and unbounded by rational methodologies) and this notion seems to aptly describe what is observed in design practice.

craftsmanship depends on a continuing involvement with practice, and over time the practice of complex skills is engrained and readily available, in other words, it becomes spontaneous and implicit in one's actions. Furthermore, Sennett also proposes to eliminate the thinking/making divide that implicitly places practice-based activities as a lesser intellectual endeavour. On the contrary, Sennett's notion of craftsmanship includes the dimensions of skill, commitment, and judgement, and a focus on the close connection between hand (the doing) and head (the thinking). It is also interesting to note the similarities between Sennett's description of practice (craftsmanship) where "every good craftsman conducts a dialogue between concrete practices and thinking; this dialogue evolves into sustaining habits, and these habits establish a rhythm between problem-solving and problem finding." (p.9) and how Schön (1983) defined designing:

I shall consider designing as a conversation with the materials of a situation. A designer makes things. Sometimes he makes the final product; more often, he makes a representation—a plan, program, or image—of an artifact to be constructed by others. He works in particular situations, uses particular materials, and employs a distinctive medium and language. (p.99)

Both authors describe the practitioner's actions as an intelligent dialogue with a concrete – but ill-defined – situation; understanding of the problematic situation emerges from the practical engagement with the circumstances of the specific situation.

Thus we gather that knowledge of how to design is troublesome to make explicit for others. Some studies support the view that designers typically find it difficult to explain how they design (Curry, 2014; Rust, 2004; Van Dooren, Boshuizen, Van Merriënboer, Asselbergs, & Van Dorst, 2014) adding weight to the notion that knowledge about designing is fundamentally tacit knowledge. Therefore, this difficulty to precisely express *how to design*, renders the dialogue between tutor and pupil in the design studio obscure – not only to an outside observer – but crucially to the students themselves; this difficulty was highlighted by Schön (1985): "Initially, the student does not and cannot understand what designing means. He finds the artistry of thinking (and doing) like an architect to be elusive, obscure, alien and mysterious." (p.31)

The design studio setting, therefore, presents a teaching/learning situation where students are expected to engage in practice without knowing what to do, under the guidance of a teacher that finds it difficult to make explicit what he knows. Furthermore, the nature of design activity makes it difficult to offer methodologies or pedagogical design methods to follow, leaving teachers with only their own experience and

common sense as guidelines for their teaching.

However, are the intricacies of teaching and learning *how* to design doomed to remain implicit? Unknowable, inscrutable, and obscure? Moreover, should studio teachers be left on their own, relying only on their experience and teaching styles as guidelines for their teaching?

1.1.4 Studies of teacher-student interaction in real-context

At the moment, definitive answers to the above questions cannot be provided because there is a considerable lack of studies that focus on real-context teacher-student interactions in a design studio setting.

This situation is surprising if we consider that there is a consensus, in design research, that the design studio setting is the fundamental aspect of design education (Cossentino, 2002; Dinham, 1987a; Goldschmidt et al., 2010; Schön, 1985). However, it is also widely recognised that there is an incomplete understanding of how the teaching/learning process in the design studio unfolds, and it is precisely the teacher-student interaction – the crucial feature of the design studio – that lacks closer examination: “Most of these sources do not go into an in-depth analysis of teacher-student exchanges” (Goldschmidt et al., 2010, p.286).

The observation that the crucial aspect of design education lacks in-depth analysis has often been noted. In early studies that focussed on the design studio (and in teacher-student exchanges in particular) Dinham (1987a) observed that: “(...) there is absolutely no published research literature on desk crit teaching, a much more private and less easily captured set of events.” (p.9) Dinham further remarks that “Desk crits form the core of the educational experience for students” (p.9),¹⁵ therefore, it is precisely the core of the educational design experience that lacks both thorough examination and is difficult to observe in a real context. Furthermore, more recent efforts in this field still highlighted the same observation: “The absence of any serious discussion of the interaction that takes place in design studio education between students and faculty is surprising.” (Ochsner, 2000, p.194)

Thus we gather that the proclaimed cornerstone of design education remains remarkably understudied. This is a problem for design education.

While the lack of studies focused on teacher-student interaction remains a shortcoming in the field of design education research, the design

¹⁵ Dinham was working within the architecture education tradition, which refers to teacher-student interactions with the term ‘crit’. The terms *teacher-student interactions*, *teacher-student exchanges*, *crits*, *design reviews*, and *one-on-one meetings*, are used interchangeably in the relevant literature; the lack of a stable terminology is a symptom of a topic in need of better understanding and clarification. We will discuss the terminology in closer detail in chapter 2.

studio educational setting – as the context for design instruction – has been the object of study of researchers working in different design disciplines,¹⁶ (see, for instance, (Salama, 1995; Schön, 1985; and Hokanson & Gibbons, 2014); these studies offer an overall perspective of the design studio educational setting, that is, they define the outline that frames the teaching/learning process of design, but the core of the design educational experience (the actual daily activity of teaching and learning how to design in a studio) remains understudied.

Furthermore, the lack of enquiry into teacher-student exchanges suggests that studies about the design studio setting have hitherto offered a top-down theoretical perspective, where considerations about *how* the teacher-student interactions unfold are frequently implied but rarely inferred from empirical observation¹⁷

Yet, there are exceptions to this situation; some authors have conducted studies based on observations in real studio contexts. These studies do not share common theoretical frameworks, have different objectives, and use different methods which hinders the possibility of synthesis and meta-analysis. Nonetheless, the studies we will mention next have gradually contributed to address this gap in design education research.

THE BEGINNING

We can trace the beginning of empirical research on the design studio setting to the studies reported in the *Architecture Education Study* (AES) (Porter & Kilbridge, 1981) book; the book presents three case studies (including first year, intermediate level, and fourth year students) based on the observation of teachers and students in a real context design studio in the USA. The AES represented a large effort illustrated by the content spread throughout the two volumes of the book. Influential at the time, the study kick-started the interest of research into studio education.

Schön (1983) developed his theory of reflective practice largely based on the analysis of one of the teacher-student interactions reported on the aforementioned book; the author's work became highly influential, thus kick-starting the interest of research into studio education. A contemporary of Schön, Dinham was another pioneer in the early days of empirical research into studio education, her studies had a broad scope (mainly focussing on student thought processes and characterising types of teacher-student interaction) and were presented in several American

16 The discipline of architecture, in particular, has a tradition of undertaking theoretical studies of the design studio educational setting.

17 It is worth noting that Donald Schön's *The Reflective Practitioner: How Professionals Think in Action* (1983) while being broad in scope, was largely based on the observations derived from a single (often cited) case study conducted in an architecture educational studio.

higher-education conferences (1987a, 1987b, 1987c) and also in a paper in the *Design Studies* journal (1989). Still in the 1980s, Ledewitz (1985) published a paper in which the author builds on the observations of studio interaction reported in Porter & Kilbridge (1981) to reflect on the pedagogical objectives of the design studio.

A SLOWLY GROWING RESEARCH TOPIC

After this initial thrust, empirical studies on the studio setting appeared sporadically and the body of literature grew slowly. We notice that authors appear to cluster around particular issues; 'formal reviews', for instance, have received some attention. Formal reviews are a specific type of teacher-student interaction in which the student makes a public presentation of a completed design project to a jury of teachers and sometimes external members as well. Therefore, formal reviews are integral to the design studio experience but – being an *evaluative* instead of *formative* experience – reviews are only marginal to the study of teacher-student interaction as the format for learning how to design.

On the topic of analysing formal reviews, Anthony (1987) combined in-studio observations with interviews of teachers and students to reflect on the effectiveness of design juries in architectural education and noted that design students particularly struggle to deal with public criticism of their work. Oak (2000), also focussing on formal reviews, observed that during their conversation teacher and student address issues that extend the project at hand; the author noted that while the conversation is centred on the project, the discussion can often go beyond and address the practice of design itself and the purpose, objectives, and nature of design education. In another study that focussed on formal architecture reviews, Webster (2005) extended the criticism presented by Anthony (1987); using a similar methodology, the author combined observations and interviews with students to conclude that formal reviews are detrimental to individual student creativity and achievement.

Another topic that authors cluster around concerns the role of language and the actual conversation dynamics between participants in the studio. For instance, Marda (1996) presented a study exploring how, in the context of the studio, the oral presentation of student work can be analysed to reveal the structure of architectural learning in the design studio. Working with similar aims, Fleming (1998) examined teacher-student dialogue in a graphic design studio and suggested that the main pedagogical function of studio conversations was to develop a shared vision of the project and only then to engage in a more systematic problem-solving process. The examination of the content of conversations was also the topic of Heylighen, Bouwen, and Neuckermans' (1999) work in which the authors showed how frequent dialogue between teacher and student

positively correlates with students developing in-depth understandings of their design, thus making a case for high frequency and intensity of conversation in the studio.

In observations of design studios and interviews with both teachers and students from different design disciplines (graphic design, industrial design, and architecture) Dannels (2005) aimed to understand the role and importance of dialogue in a design studio setting. The author's analysis suggests that frequent teacher-student dialogue fosters the development of skills such as the ability to verbally explain the design process, information analysis, and use of design language, and crucially, the conversations introduce the student into the culture of professional design. Later, working with Martin (2008), the author also looked into the types of teacher feedback that occur in the design studio.

Sill within the topic of language use, Goldschmidt & Avidan (2013) presented a study that challenged the notion that language is inferior when compared to the role of visual representation in design. On the contrary, the authors suggest verbal expression is an essential part of designing, particularly when explaining concepts during the design process. The study reports on a correlation between the frequency of evolving concepts and the final studio grade, that is, the authors found that the more a concept changed and the more links between concepts made by the student during the process the higher the final grade (which is consistent with what Heylighen et al. [1999] had concluded as well).

Concerning the issue of teacher-student dialogue, Cennamo & Brandt's (2012) study collected and analysed data from studio classrooms from three design disciplines (namely architecture, industrial design, and human-computer interaction). The findings provide insight into how dialogue with the teacher decisively support students as they learn to tackle ill-structured design problems; also, in line with what Oak (2000) and Dannels (2005) suggested, the authors stated that dialogue with a design teacher is a mechanism that introduces students into the particular practices and language that reflect the professional world of design.

On the topic of knowledge transmission during teacher-student interactions, Uluoglu (2000) addressed the issue of what kind of knowledge is transmitted in studio critiques. The author suggests that the critical aspect of design education is to guide the student to understand that design is a self-conscious and reflective activity, a point which is consistent with what Schön gathered from his articulation of reflection-in-action. Uluoglu submits that it is difficult to arrive at a stable and consensual definition of what is the general knowledge of design, which in turn makes it difficult to reach a single (general) way of teaching design. This leads the author to conclude that teaching how to design is based

mainly on individual knowledge and experience, but the author also proposes that theoretical work should aim to understand what brings those individual teaching experiences together.

On the topic of knowledge transfer in the studio, Elmers (2014) looked into how (and if) students were able to transfer what they learned between projects by employing questionnaires in-between project assignments. The author compared the results to see if there was an increase in the ability of the students to reflect on their work and then transfer that knowledge to the next project. Elmers observed that successful knowledge transfer between projects was primarily based on overall student ability and thus suggested that the typical design studio setting may lack mechanisms that foster this ability in all students. Green (2005) focussed on examining if students employ explicit design methods during project work: the author conducted several studio observations but primarily based his analysis on the results of student questionnaires; the results of his research suggest that students only marginally integrate explicit design methods into their product development strategies.

A few authors have also examined how students' design process unfolds in the studio setting. From this point of view, Sachs (1999) presented an influential paper reporting on how students are often stuck during their design process; the author describes *stuckness* as a breakdown in the students' capacity to respond to the studio requirements, accompanied by the recognition that they are stuck. The author suggests that design students' *stuckness* is probably related to a combination of obstacles, chief among them a difficulty to address design project requirements, confusion over the design process and a misunderstanding of the teacher's intentions and feedback.

Focussing on the design process but from the perspective of creativity Hasirci & Tuna (2012) report a study that explored the role of literature in fostering creativity within a design studio context. The authors found that interior architecture students that included poetry as a complimentary feature to their creative design process presented more original final results; a finding that aligns with Goldschmidt & Avidan's (2013) point that language could be as important as visual representation during the design process.

On a different focus, Goldschmidt (2002) build on a few episodes of studio interaction to explore the details of teacher-student communication and its implications for the student's learning process; from the examples, the author was able to articulate the different roles that the teacher adopts during conversations in the design studio, namely that of coach, expert, and colleague. Furthermore, Goldschmidt suggests that the teacher's role can be synthesised into two main roles: the *role model*, who excels in the

practice of design, and the *educationist*, whose expertise rests in teaching; the former is more practical-minded and teaches by example (by *showing*), and the latter stands back and mostly teaches by articulating knowledge (by *telling*). Both categories have also been identified in Schön's *Educating the Reflective Practitioner* book (1987).

Later, working with Hochman & Dafni (2010), Goldschmidt detailed teachers' performance in the design studio, showing how they alternate between different action priorities depending on students' particularities. The authors found that design teachers often combine the articulation of general issues pertaining design and the specifics of the project in hand, and navigate the thin line between demonstrating solutions for the students while not designing the project for them. Goldschmidt et al. also suggest that over-reliance on encouraging students to come up with solutions by themselves may frustrate them and hinder the development of the project and lead to *stuckness* (Sachs, 1999).

In a study based on observations of architecture studio conversations, Utaberta, Hassanpour, Che Ani, and Surat (2011) identified and presented an overall perspective on the types of critiques used in the design studio setting. The authors then discussed the merits and shortcomings of each type of critique and emphasise the importance of having clearly articulated assessment criteria, arguing that consistency in criticism and assessment should lead to more explicit expectations from the students. Mewburn (2012) aimed to expand Schön's description of design teaching and learning. The author examined teachers and students in action in the design studio to suggest that while Schön's theory may be accurate in describing to teachers their experience of designing, it is less helpful when articulating the practice of teaching in the studio, especially when tutoring students who are no longer novices.

Some authors have delved into the studio to consider the broader context that frames teacher-student communication. Strickfaden, Heylighen, Rodgers, and Neuckermans (2006), delved into the studio sessions of an industrial design course with the purpose of examining the role of culture in the creation and development of artefacts. In this study the authors report that the students were observed and interviewed within the studio setting while they were designing, which interestingly places data-gathering at the heart of the observed phenomena. Strickfaden et al., conclude that cultural capital exists within both teachers and students and culture is a contributing factor in the development of an artefact. However, the authors remark that students often feel they have little support from their teachers in guiding them to be self-reflective concerning the impact of cultural capital in their project development.

Similarly to Green (2005) and Strickfaden et al. (2006) McClean &

Hourigan (2013) conducted fieldwork on the design studio but mostly aimed to capture the learning experience through questionnaires. The authors found that the informal peer interaction that unfolds in the design studio is complementary to the direct learning experience of tutor interaction; therefore, the authors place teacher-student dialogue as just another instance of a multitude of peer-interactions that take place in the design studio. Then, McClean et al., articulate the specific properties of both informal and formal feedback and the contribution each makes to studio-based learning.

DTRS SYMPOSIUM

A recent research symposium made a significant contribution to address the gap in the research literature concerning studio interaction: the 10th Design Thinking Research Symposium (DTRS10) held at Purdue University, Indiana, USA, in October 2014. The theme of the symposium was *design review conversations* a term broadly defined as the conversations between those who give and those who receive feedback, guidance, critique or mentoring during a design review (Adams, McMullen, and Fosmire, 2016). Therefore, the symposium focussed not only on teacher and student communication, but instead adopted a broader perspective of studio interaction that includes clients, peers, professional designers, or other stakeholders in a project. The symposium resulted in a special issue in Design Studies journal (Adams, Cardella, & Purzer, 2016) a book based on the symposium *Analyzing Design Review Conversations* (Adams & Siddiqui, 2015) and a special issue of the CoDesign journal (Adams, McMullen & Fosmire, 2016.)

We were invited to participate in the symposium during the making of this thesis; a full account of our study is presented in Chapter 6 of this thesis which is largely based on a book chapter (Ferreira, Christiaans, & Almendra 2015) of the aforementioned publication and a paper (Ferreira, Christiaans, & Almendra 2016) in the special issue of the CoDesign journal.

The DTRS10 invited researchers to work with a shared dataset that consisted of video-recordings and respective transcriptions of design reviews across different disciplines, studio structures, and design project phases. The dataset also included other elements such as digital presentations, storyboards, and images of student prototypes. Participants captured in the recordings included students working individually or in teams on projects in the disciplines of choreography, entrepreneurial design, industrial design, mechanical engineering design, and service-learning design.

The researchers approached the dataset with different objectives, and naturally, there were some who focussed primarily on teacher-student

interaction in the design studio. For instance, McDonnell (2016) described how design expertise is acquired through the experience of designing with a teacher and also how the conversations assist novice designers to develop their individuality as a designer. The author draws on the teacher roles presented by Goldschmidt (2010) to characterise the discourse between the tutor and his students; McDonnell describes how the roles are mostly enacted by speaking and that the teacher plays an integral part in introducing the student into the design profession by modelling how a designer might think and act during the design process.

Also focussing on the connections between design education and professional design, Sonalkar, Mabogunje, Leifer, & Roth (2016) examined several teacher-student interactions to identify patterns that reveal the emergence of professional design vision, meaning those moments when a teacher exhibits ways of seeing and interpreting that are specific to the design profession. The authors suggest that these moments are crucial to the effectiveness of a design review as a learning situation. In the study, the authors identify patterns of interaction (namely: question-asking, supportive behaviour, building-on behaviour and humour) that often led to displays of professional vision from the teacher.

Further concentrating on the role of the studio teacher, Adams, Forin, Chua, & Radcliffe (2016) characterise the work of teaching in the studio using a framework (the pedagogical content knowledge framework) that aims to clarify the teachers' integrated knowledge of the how, what, and why of coaching during design reviews. In the study, the authors identified and described four patterns of coaching: scaffolding articulation, driving for meaning and guidance, breaking the 4th wall to create a teaching moment, and letting the students figure it out on their own. Yilmaz & Daly (2016) based her work on the teacher's role as well but with an aim to describe feedback; the author analysed feedback in different disciplines (choreography, industrial design, and mechanical engineering) to explore variation in feedback across disciplines. Interestingly, the authors identified that feedback that encouraged convergent thinking was more prominent (across all three disciplines) than divergent thinking.

Oak & Lloyd (2016) explored what the authors termed collaborative micro-activities (such as speech, gesture, and gaze direction) as an essential part of communication in a design review; the authors articulated the impact that these micro-activities have on the participants' experiences and perceptions of design education, particularly during group reviews such as the one reported in the study. Oak and Lloyd highlight the impact that the teacher had on the review when he required the students to criticise the work of their peers. As the meeting unfolded, the role of authority shifted between participants who had a decisive impact in the review sessions. Also, the study adds to other studies in suggesting

that the analysis of teacher-student communication should expand beyond the role of verbal language to include the analysis of non-verbal communication.

On a similar note, Tenenberg, Socha, & Roth (2016) investigated the physical stances that designers adopt concerning one another during design critiques. From the analysis of critiques between students and professional designers in industrial design, the authors suggest that (besides verbally narrated) design concepts can be communicated through gesture, gaze, orientation and body movement.

Taking a different focus, Tolbert, Buzzanell, Zoltowski, Cummings, & Cardella (2016) explored the purpose of visualisation and artefacts during a design critique. The authors describe the reviews as a social process in which the teacher, students and artefacts serve a role in the design critique. Throughout this social process, the authors observed how the teacher and students used visualisation to either reduce or explore ambiguity. In particular, Tolbert et al. observed how the teacher created visualisations using artefacts to understand the students' design ideas.

From a completely different perspective, Dong, Garbuio, & Lovallo (2016) analysed teacher-student conversations – from the undergraduate industrial design course and the entrepreneurship course – to explore manifestations of design thinking. Teacher-student interaction proved a fruitful context to study this issue since the authors were able to disclose a new pattern of design thinking that they named generative sensing (a pattern that helps designers – during concept evaluation – to navigate a design problem by recursively testing propositions.)

The contribution of the studies mentioned here helped mitigate the recognised lack of empirical inquiry into the design studio, but considering the importance of the studio setting to design education there is still considerable work to be done. Furthermore, the nature of teacher-student interaction means that studies (particularly explorative and descriptive studies) tend to have small populations. Also, a single observation of a teacher-student dialogue may take several months before producing any results (particularly if we consider the whole research process: data-gathering, data-processing, analysis, discussion, publication), making teacher-student interaction a particularly difficult object of study, which might account for the scarcity of studies.

It is imperative that more field studies be conducted in the natural environment in which teacher-student interactions commonly occur if we are to develop a detailed understanding of the frequently acknowledged crucial aspect of design education. This topic has lacked systematic study and empirical research.

1.1.5 Observing real-context design conversations

Hitherto, most research has focused on either theoretical considerations about the design studio that lack a foundation on empirical observation, or laboratory studies of student performance that do not attend to the dynamics, constraints, and conditions of the design studio setting.

Additionally, there is a recognition that knowledge of how to design is mostly tacit knowledge and the conversations between teacher and student in a design studio are somewhat obscure since the dialogue is fundamentally self-referential and bounded to the specific context of a design project. It follows that in a design conversation the words uttered while designing cannot be separated from the practice in which they occurred without becoming partly devoid of meaning. The situatedness of design activity in the design studio supports the need for observational studies conducted in real-context settings. Despite this observation (and a consensus about the crucial role played by teacher-student interactions for design education) there is a notorious lack of studies conducted in real design studio educational settings.

The lack of empirical research on this topic means that there is not a stable body of studies from which to build on. Providentially, the case study presented by Schön (1983) offers a research template to follow. The study reveals how the tacit knowledge of an experienced designer can be communicated to the student during a design conversation. In the study presented by Schön, we observe that the teacher recurrently punctuates his tutorial with verbal explanations that (in combination with the use of sketches) are meant to make the design process more clear for the student as they both work on a design project. This is what Schön described as the language of designing, which – as we have already stated – is a defining characteristic of the dialogue that unfolds in the design studio; as Heylighen et al. (1999) noticed:

Doing so, the teacher speaks the language of design, i.e. the language of doing design, which involves both sketching and talking. Rather than describing what is already on the paper, the talking parallels the process, thus making it more accessible to the student. (p.219)

1.1.6 Design language – a common language between teacher and student

This research proposes to develop the concept of design language as a framework to analyse teacher-student dialogue in real-context design studio settings. Design language can be a particularly useful framework for analysis because it highlights what remains implicit in the practice of designing. The language renders the design process at least partly explicit since the tacit elements of designing must be clarified by the teacher to

help the student grasp them. In this *explaining in practice*, teachers make their design process more clear and visible to their students.

Furthermore, Schön presented design language from the perspective of the teacher, that is, the author mostly focused on how design language was employed by the teacher to communicate with the student. However, we gather that a design conversation is fundamentally a dialogue, and therefore it is expected that the student also uses design language to communicate back to the teacher. In fact, the student is simultaneously learning and tentatively applying design language during the conversation with the teacher.

Therefore, design language can be understood as a common language between teacher and student. This understanding provides possibilities for analysis, namely the disclosure of similarities and differences between teacher and student uses of the language. The comparison between different design language should reveal the inherent dynamics of the studio thus eliciting its analysis and potential insights. Furthermore, we can also compare differences of design language use between students at different levels: proficiency in design should entail a growing fluency in the language of design, which means we expect advanced students to exhibit a higher fluency on design language than novices.

1.2 Research scope, aims, questions, and relevance of the topic

1.2.1 Research purpose & scope

The purpose of this thesis is to describe the process by which teaching and learning how to design occurs.

This process is fundamentally a dialogue that takes place in the design studio setting. The dialogue is conducted by teacher and student while focusing on a design project; this is so because the design studio is a practical educational setting where students learn by doing, that is, by practising designing under the supervision of a design teacher.

This dialogue is a defining feature of design education. Therefore we think it requires a distinctive terminology. We propose to use the term *design conversations* to describe the several manifestations of one-on-one dialogue between a teacher and a student while working, presenting, or reviewing a design project.

A distinctive aspect of a design conversation is that it is conducted with a particular language – the language of design (the fundamentals of which

have been laid out by Schön [1983, 1985]). Design language is primarily an expression of the design process, that is, it communicates aspects of the activity of designing as it unfolds; since learning how to design is the central objective of design education it follows that by analysing the language we should uncover (part of) the educational process.

The definition of the scope of this research establishes two key areas of investigation: (1) the design studio as the overall setting where design conversations occur; and (2) the one-on-one dialogue between teacher and student as the central moment to observe during project work in the studio under the focus of the design language framework.

From the first point emerges the requirement to describe the design studio regarding its defining aspects, i.e. identify what the critical features of the design studio setting are. In essence, it is a matter of developing a descriptive model that establishes the limits that frame the object of study, which concerns the student-teacher interactions.

Concerning the second point, we are interested in building on Schön's description of design language to constitute an observation framework that will enable the analysis of the verbal¹⁸ output of teacher and student. This framework will allow a comparison of the discourses of both, which in turn permits the disclosure of patterns (if there are any) not only between teacher and students but also between different teachers and novice/expert students.

The two main topics are connected in the following manner: the development of a descriptive model of the setting provides the guidelines for the analysis of the conversations. An empirical observation of teacher-student interactions that does not take into account the constraints of the design studio could risk becoming disconnected from the general context in which they take place. The defining characteristics of the design studio may influence the teacher-student interactions. Studies of teacher-student interaction should, therefore, combine a theoretical description of the design studio setting with real-context studio observations.

Thus, the design conversations are analysed at the level of the observed phenomenon, whereas the development of a model of the design studio setting is part of the theoretical framework. Subsequently, it is expected that analysis of the observations might reveal insights that alter the understanding of the model.

¹⁸ It should be noted that Schön's concept of a language of design states that it is both a form of visual and verbal expression. We acknowledge that a simultaneous study of the visual and verbal aspects of design language could contribute to a broader understanding, however, such a study would require the use of two completely different methodological approaches, observation procedures and analytical tools, and therefore is beyond the scope of a single thesis.

Finally, it is important to clarify that the focus of this thesis is directed at the student-teacher interaction in the specific context of the design studio. As we have seen, the teaching/learning of design is directly linked to the practice of design; pedagogical implications are thus specific to the discipline of design. Therefore, general pedagogical considerations fall outside the scope of this thesis.

1.2.2 Research aims

The main objective of this research is to describe how the educational process unfolds in the design studio. The aims we list here concur to address that central goal.

Research aims:

- The development of a model of the design studio setting that accurately describes its defining features regarding how they influence the teacher and student interaction.
- Make the content of teacher-student interactions more explicit.
- Compare how teachers and students use the language of design during design conversations and identify the key differences between them.
- Propose a taxonomy of teacher and student interactions in the design studio.
- Critically analyse the current terminology on this subject and contribute to more stable definitions.
- Identify key aspects to explore in future research, with an emphasis on the development of guidelines for the teaching practice of design teachers.

1.2.3 Research questions

This is an exploratory research that aims to describe how the teaching and learning process of how to design unfolds in the design studio. The research questions we present here serve to frame the research, the questions were clarified and improved from initial pre-assumptions that focussed our approach and allowed us to go to the field and conduct observations in real-context design studio settings. The research questions are exploratory and mainly serve as guidelines for the research studies.

1. What is the result of design conversations?

- Do design conversations reveal new knowledge about design and designing? If so, to what extent do students reveal they have apprehended it?

- Do design conversations influence the design project?
 - Do design conversations influence the student's design process?
2. What is the role of design language in design conversations?
- Does the design language model reveal the design process of teachers and students and render it more explicit?
 - What are the differences and similarities between teacher and student use of design language?
3. How do the defining features of the design studio influence the dialogue between teacher and student?

1.2.4 Relevance of the topic

In general, the findings of this research will contribute to expand our understanding of design education. The studies that make up this research aim to uncover critical areas in the design educational process that have remained hitherto unexplored. From a broad perspective, we gather that the design studio setting is also a form of design practice – students learn by doing, i.e. by designing – therefore, it is expected that the findings of this research might contribute to the growing understanding of the design process in general.

The main contribution of the research is that it addresses the lack of studies conducted in the natural setting of teacher and student interaction: the focus is placed on the teacher and student dialogue in the design studio. Our research approach includes a model of the design studio setting and an observational framework (based on Schön's proposed language of design) that specifically addresses the tacit knowledge of designing and endeavours to make it more explicit.

The framework of analysis permits comparisons between the teacher and students' discourse, and in turn, this analysis can reveal some of the gaps that exist between an expert in design and a novice. Identifying these gaps can lead to a reflection on ways to address them, and to devise strategies to bridge them. Furthermore, the research also reveals the fluency in design language of students in different stages of development, thus permitting the comparison between novice and advanced design students.

Also, the observation of different teachers (with different discourse and teaching styles) permits a comparison of how different teaching styles influence the dialogue with the students. Therefore, this research contributes to the daily practice of teachers in the design studio in the following way: the observational framework could be useful for teachers in their daily practice as a way to monitor their performance, track how the students are evolving, and if the teaching style is working; i.e. it could

be revelatory for teachers themselves. Hitherto, there are few guidelines, tools, and models that can be helpful for design teachers in their daily practice.

Additionally, the analysis and careful description of one-on-one teacher-student meetings have the potential to establish links between design research and the actual practice of teaching in the design studio. The results from the set of studies that make up this research can begin to disclose patterns and identify key issues and questions for further inquiry, thus contributing to the body of knowledge on design education.

This research also concerns the design studio as the setting where design conversations occur. Since the research combines theoretical analysis with empirical field work, we can feed one into the other and make a critical reading of the existing theories and frameworks of design instruction. The research includes a model of the design studio that constitutes a proposal to clarify some terminologies and taxonomies; thus far, the relevant terminologies and taxonomies of teacher-student interactions have been used inconsistently between different design researchers. Therefore the proposed model contributes to achieving more stable definitions.

To sum up, this research addresses a long-standing lack in design research and opens possibilities for further exploration, and fundamentally contributes to expand the limited body of knowledge available to those who are interested in understanding the design studio teaching/learning experience.

1.3 Research methodology

In this section, we describe the overall methodology of this research. The specific methods employed in the observation and analysis of the case-studies are detailed in the *methods* section of each study (presented in Chapter 3).

The methodology for this research responds to the following conditions:

a) Considering the contextualisation of the problem, it is clear that the current understanding of teacher-student interaction in a design studio setting is incomplete, in particular, the knowledge that emerges from real-context observations is still lacking. The object of study requires preliminary mapping out, clarification of terminology, and critical analysis of existing taxonomies.

b) Additionally, not only is our knowledge about teacher-student

interaction still in a preliminary stage, but also data concerning real-context interactions in a design studio is difficult to collect and analyse.¹⁹ For the researcher on this subject, there are two general difficulties that arise from this setting: (1) the teacher and student meetings that take place in a design studio are often unpredictable due to the unstructured nature of a studio session when compared with a typical university lecture class; also, the one-on-one meetings are predominantly private encounters that take place in an intensely socialised space (Wang, 2010) into which an outside observer (such as a researcher) is intruding; (2) teacher-student interactions can be considered a form of designing, and research on design activity has mostly been conducted in controlled experiments, therefore to the unpredictability of the design studio setting is added the unpredictability of design activity.

These circumstances require an exploratory research methodology with a predominance of qualitative methods.

The purpose of an exploratory methodology is to map out a topic for which there is little knowledge available (Babbie, 2013). Exploratory research is broad in focus and seldom provides definite answers to specific research problems. The objective of exploratory research is to identify key issues and variables of a research topic and establish the foundation for descriptive and explanatory studies to be conducted later.

Bhattacharjee (2012) states that the goals of an exploratory research study can be summarised as: (1) to determine the scope of a particular phenomenon, problem, or behaviour, (2) to generate initial ideas about that phenomenon, and/or (3) to inquire the viability of developing more extensive studies regarding the phenomenon.

Thus, the research design will employ an *exploratory* research approach which is adequate considering that the setting requires mapping out, combined with a *descriptive* one. The purpose of descriptive research is to make careful observations and develop detailed documentation of a phenomenon. Descriptive research seems a reasonable approach for a topic that has been (to date) broadly defined but seldom confirmed in empirical observations. While the design studio is a broad field of inquiry, this thesis is focused on a precisely defined aspect of its setting: the design conversations that unfold between teacher and student. As such, it is possible to consider this phenomenon in itself and to analyse and describe it in greater detail.

Therefore, regarding methodology, this thesis can be described as both

¹⁹ The difficulties of conducting situated studies (instead of experiential ones, where the researcher determines and controls the variables and context) in a design studio setting could be an explanation for the lack of studies concerning this subject.

exploratory and descriptive, with a predominance of qualitative methods. The research design was developed to map the design studio setting and to uncover indications, patterns, and insights about how the teaching/learning process unfolds during design conversations, and fundamentally to disclose part of the tacit knowledge of designing being used and making it more explicit.

Finally, the exploration of this topic requires in-depth analysis of examples of design education in practice; therefore, case studies of real design studio educational settings are a fundamental part of this research. The research is structured with the objective of disclosing new knowledge about the design studio mostly from empirical observations in the natural environment in which design conversations occur.

1.3.1 Research design

The research is structured in three main stages: (I) Exploratory (II) Descriptive, and (III) Synthesis.

I. Exploratory

This stage is constituted by three activities carried out in parallel. A literature review was conducted simultaneously with both observations of teachers in practice and tutoring experiences by the author of this thesis.

(1) Literature review: we conducted a literature review of the relevant topics that frame this thesis. The overall topic is the design studio as an educational setting, with an emphasis on describing what the distinctive elements that make it a particular educational setting for design education are.

The other main topic concerns the notion of the dialogue between teacher and student as the fundamental unit of analysis of our studies. As such, building on the groundwork proposed by Schön (1983, 1987), we will elaborate on the concept of a *design language* as the observational framework for the analysis of teacher and student dialogue. We propose a descriptive model of design language with the aim of applying it as an observational framework; this means to describe the two dimensions of design language: (1) Meta-design discourse, and (2) Design grammar.

A synthesis of these two topics constitutes the analytical framework used to analyse the data collected during the observations.

(2) Observations: this part of the exploration corresponds to the observation and collection of data of teacher-student interactions in real design studio contexts.²⁰ By moving to the field immediately, it was

²⁰ Specific methods on data collection and analysis procedure for each case study are detailed in chapter 3.

possible to question what was found in the literature and to consider questions that might not have arisen without having had the experience of observing design teachers in practice. The rationale was that a nuanced understanding of the subject should emerge from the combination of the two distinct ways of investigating the object of study.

(3) Tutoring: an important part of the initial research was the time the author of this thesis spent as a tutor in a design-studio. This field experience started early in the research process and was prolonged throughout the investigation. The first-hand experience of teaching undergraduates and master students *how* to design was an invaluable complement to the literature review and observation of other teachers conducted during the research. While this first-hand experience was not translated into data to be analysed, it was part of a triangulation with the literature review and the observation of teachers in real design studio contexts.

II. Descriptive

This stage corresponds to the analysis of the data collected during the observations of teachers in practice. In this stage, we apply the design language concept as an observational framework. We divided the studies into two parts:

(1) The case studies: this is the primary part of our studies. From the observations we gathered four different case studies. Each case study presents the real-context observation of a pair of participants (one teacher and one student) except case study 3 which includes two pairs (two teachers and two students).

The four case studies include students enrolled in different course years (from first-year undergraduates to master students). The case studies we conducted follow the same methodology and apply the same observational framework. Each case study report include the methods, the context of observation, the verbal reports, results, and the discussion of the findings. The table below presents an overview of the case studies (the real names of the participants have been replaced with pseudonyms).

CASE STUDIES		
Case study	Course year	Participants
Case study 1	2 nd year undergraduate	Ella (<i>teacher</i>) Dylan (<i>student</i>)
Case study 2	1 st year undergraduate	Grace (<i>teacher</i>) Janis (<i>student</i>)
Case study 3	1 st year master	Albert (<i>teacher</i>) Paul (<i>student</i>)

CASE STUDIES

Case study 4	1 st year master	Robert (<i>teacher</i>) Patti (<i>student</i>)
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Table 1: Overview of case studies

The overall case study research approach followed the methodology presented by Robert K. Yin’s *Case Study Research: Design and Methods* (2008). The four case studies correspond to four cross-sections²¹ of the same phenomenon – design conversations, i.e. teacher-student dialogue in a design studio setting during project work. The observations were conducted at random points of project development, and there was the preoccupation to intrude as little as possible in the proceedings.

The primary focus is the analysis of the participants’ verbal output under the lens of the design language observational framework. The verbal output analysis is conducted in conjunction with the field notes to base the conversational analysis in the context in which the observations took place. Furthermore, the defining features of the design studio are also taken into consideration when analysing the teacher and student dialogue.

The central part of the analysis is the sequential presentation of the design conversation. The report and analysis of the dialogue follows the template presented by Schön (1983) in his case study of Quist (studio teacher) and Petra (student). However, while Schön opted to highlight only the parts of the conversation that illustrated his theory, the verbal reports we present are more extended. That is, the case study reports are structured in a narrative form (following the beginning, middle, and end of the interaction); the purpose of this format is to allow a comprehensive reading of how the interaction unfolded. Thus, the back-and-forth dynamic of the design conversations are rendered almost in full²², instead of presenting only highlights that are necessarily determined by the researcher’s interpretation. As such, the researcher’s interpretation of the conversation is presented as the dialogue unfolds. We propose that this is an adequate format for presenting detailed design conversations since our procedure for interpretation of the dialogue is fully disclosed. Thus, the results are clear and could serve as the basis for further research, or alternatively disagreed with.

(2) The Design Thinking Research Symposium study: this study follows the previous case studies. While the research approach is the same one that informed the case studies, there is one (important) difference which

21 A cross-sectional study is the study of a specific phenomenon at a given point in time; it differs from a longitudinal study which conducts a series of observations repeatedly of the same participants over a period. (Babbie, 2013)

22 Of course, some editing had to be made to keep the page length reasonable and for readability purposes. As such, the verbal protocols are presented in full in the annexes.

concerns the methods of data-collection; in this study, the data was not collected by the author of this thesis but accessed in a video and verbal transcript database.

Furthermore, this study was conducted in the context of the Design Thinking Research Symposium,²³ the discussion that took place during the symposium – as well as the one conducted when producing the book and special journal papers – greatly influenced the analysis, discussion, and conclusions of this study.

The study consists of the analysis of nine design conversations between a teacher (Gary) and seven third-year undergraduate design students. The database presents interactions unfolding at different points in project development. Two students (Sheryl and Todd) have two interactions with the teacher, while the other five account for one conversation each. The table below presents a summary of the participants in this study.

DTRS10 Study		
Year	Participants	
3 rd year undergraduates	Teacher	Students
	Gary	Adam, Addison, Alice, Esther, Lynn, Sheryl (2x), and Todd (2x).

Table 2: DTRS Study participants

The analysis follows the same approach as the one applied for the case studies. However, during the symposium we were encouraged to develop and use a visual diagram as a tool to present and analyse the verbal data; details about the development of the visual diagram tool and implications of its results are detailed in Chapter 6.

III. Synthesis

This stage concludes the research process. It includes a cross-case analysis of the case studies and a discussion that compares the empirical findings with what was established in the literature review and finally a discussion of the implications for the problem statement, research aims, and questions. The figure below presents a diagram of the research design.

²³ The Design Thinking Research Symposium 10 took place between 12 and 15th of October 2014 at the Purdue University in Indiana (USA) and was constituted by multiple design researchers analysing the same database.

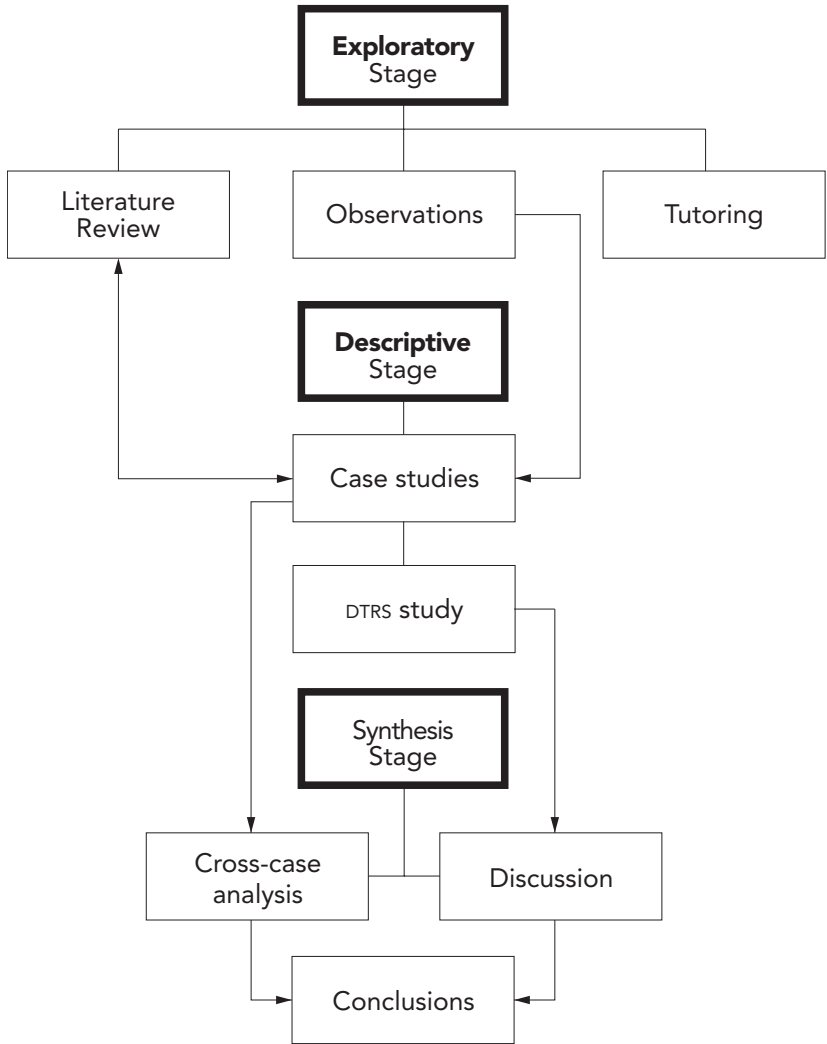


Figure 1: Research design.

1.4 Outline and structure of the thesis

This thesis is structured in four parts that spread across eight chapters. The chapters are preceded by the title page, epigraph, acknowledgements, and the general and figure index. The postscript includes the bibliography and appendixes.

Part 1 - Research contextualisation

Chapter 1 – Introduction

In the first part of the thesis, we introduce the topic and present the overall research approach. The chapter begins with the problem statement which concerns the intricacies and challenges of teacher and student dialogue in a design studio setting.

Next, we focus on the purpose and significance of the thesis by stating how it contributes to design research. We highlight what is lacking in the understanding of teacher and student interaction and propose an approach and overall methodology to address it.

The chapter concludes with a presentation of the thesis outline and structure.

Chapter 2 – Theoretical Framework

In the second chapter, we expand on the issues raised in chapter 1. We proceed by outlining the pedagogical significance of the design studio for design education and highlight the defining features of the setting. This chapter is the result of a critical literature review where we elaborated on the fundamental concepts that frame our object of study. The critical reading we present constitutes the theoretical framework that structures our research.

This chapter focuses on three areas entitled: (1) Design studio, (2) Design conversations, and (3) Design language. In these sections, we expand on the concept of a design language proposed by Schön and operationalise it in an observational framework.

The chapter ends with a final section – entitled: design studio model – that concludes the theoretical framework by proposing an observational model for the empirical studies; this is accomplished by relating the proposed model of the design studio with the design language theoretical framework. The model of the design studio includes a taxonomy of design conversations and the identification and description of the key features of the design studio setting.

Part 2 - Case studies

This part of the thesis concerns the observations of teacher and student one on one interaction in real context studio settings, the observations are presented in three chapters: **Chapter 3** presents the methods used in the case studies, **Chapter 4** presents two case studies with undergraduate students, and finally **Chapter 5** concerns two case studies with graduate students.

The observations correspond to a series of four case studies conducted in real-context design studio settings. The design studio model we presented in chapter 2 provided the guidelines used to conduct and analyse the observations in the design studio.

Each case study report includes an account of the methods, the context of observation, the verbal reports, results, and a discussion of the findings. Each report closes with a conclusion, and as the studies progress we build on the previous conclusions and compare the findings.

Part 3 - The Design Thinking Research Symposium study

Chapter 6 – DTRS study

In this chapter, we present a study that is based on our theoretical framework but uses slightly different methods.

The research approach is the same one that informed the case-studies, but with the difference concerning the methods of data-collection; as such, in this study, the data was not collected by the author of this thesis but accessed in a video and transcript database of the Design Thinking Research Symposium. The symposium involved sharing a common research dataset of video recordings of design conversations between teachers and students. The study we present here includes nine interactions between one teacher and seven students.

Part 4 - Discussion, conclusions, and recommendations

Part 4 concludes the thesis by relating a broad discussion of the empirical findings with the initial contextualisation of the problem. This part of the thesis includes two chapters.

Chapter 7 – Discussion

In this chapter, we discuss the results of both the DTRS study and the case studies. We relate these to the theoretical framework as well as to the problematisation presented in Chapter 1. In this chapter, the significant findings of the research are highlighted, summarised, and related to design research in general.

Chapter 8 – Conclusions and recommendations

The final chapter presents broader conclusions regarding the object of study of design conversations, and address how the empirical results have implications for the problems raised in the problem contextualisation. In this chapter, the focus is on highlighting the significance of our findings for the practice of (and research about) design instruction. Finally, the thesis concludes with recommendations for future research as well as for design teachers. The thesis structure is presented in the table below.

THESIS STRUCTURE		
		<i>Problem statement</i>
Part 1 Contextualisation	Chapter 1 Introduction	<i>Relevance, scope, questions, and aims</i>
		<i>Research methodology</i>
		<i>Outline and structure of the thesis</i>
Part 1 Contextualisation	Chapter 2 Theoretical framework	<i>Design Studio</i>
		<i>Design conversations</i>
		<i>Design language</i>
		<i>Design studio model</i>
Part 2 Case studies	Chapter 3 Methodology	
	Chapter 4 Undergraduates	Case study 1 <i>Grace & Dylan</i>
		Case study 2 <i>Ella & Janis</i>
	Chapter 5 Graduates	Case study 3 <i>Albert & Paul</i>
		Case study 4 <i>Robert & Patti</i>
Part 3 DTRS	Chapter 6 DTRS study	
Part 4 Conclusions	Chapter 7 Discussion	
	Chapter 8 Conclusions & recommendations	

Table 3: Thesis' structure.

Chapter 2

Theoretical framework

2.1 Introduction

In this chapter, we will describe the theoretical framework that supports this thesis. The section is divided into three main parts (design studio, design conversations, and design language) with each one describing a key feature of the design studio setting.

2.1.1 The problem of lack of empirical studies

As we have seen in chapter 1, there is a notorious lack of empirical studies concerning teacher-student interaction in the design studio environment. This is the case despite the many studies that focus on the work – and in particular on the process – of design students (Eastman, Newstetter, & McCracken, 2001). However, these type of studies can be equivocal in two ways: on the one hand, the conclusions about the design process can be misleading because students are not experienced designers. They are, by definition, novices. Furthermore, the conditions in which designers work is hard to simulate in a laboratory setting:

This may represent a very respectable form of research but it is extremely difficult to conduct with a sufficient degree of realism to be relevant to what those designers actually do in practice. The designer is still effectively in a laboratory rather than the normal studio. Timescales are compressed, collaborators and clients are absent or simulated, there is seldom open access to design precedents, no other activity takes place in parallel so there is little time for reflection and so on (Lawson, 2005, p.288).

On the other hand, in laboratory studies, the conclusions about design teaching and learning are also limited because nearly the entire learning context is removed. The dynamics that are a part of the ongoing teaching/learning process must certainly have an impact on student learning, but since the real context of the design studio is removed, we are left with a reduced point of view.

Therefore, data on teacher-student interaction in a real context design studio is rare. And yet, the scarcity of empirical studies does not prevent the literature about design education from having many pre-established ideas about how the learning process of design unfolds (we are referring here mainly to attempts to import the model of the design studio to other disciplines, see, for instance [Brocato, 2009; Vrcelj & Attard, 2007; College, 2001; Cossentino, 2002; Kellam, 2013]). These conclusions are, at the most, deduced from a theoretical understanding of the design studio, and rarely induced from observation or even confirmed in observations of the practice of design teaching in real context.

Moreover, the lack of studies does not prevent some authors from publishing global critiques on the design studio as an educational setting. The main shortcomings of these evaluations include the fact that their starting points are not substantiated in studio observations. For instance, from a psychoanalytic point of view, Ochsner (2000) speculated that – similarly to children and play – “making students prematurely self-conscious about engaging in design may impinge upon their ability to do so freely.” (p.202) Anthony (1987) analysed the impressions of students about final evaluations conducted in front of a faculty jury and concluded that students dreaded the experience with final juries. The author expands on her findings to characterise the jury experience as a shortcoming of learning in the design studio. And yet, it would seem that the author took the part for the whole. Notice that the design studio is an ongoing educational setting, therefore evaluative moments (such as the juries described in Anthony’s paper) are the exception and not the rule in the studio since evaluations in front of a jury happen, at most, once per semester. Nevertheless, as a critique of the assessment of students’ work by architectural juries, the criticism of Anthony is precise, if only because it highlights how counter-intuitive it is to the overall educational ethos of the design studio.

Another oft-quoted study is Cal Swann’s “Nellie is dead”(2002) paper in which the author suggests that the design studio setting should be altered. It should be noted that while Swann’s article is the result of field experience, this practical experience is unfortunately not described in the paper. There are also a couple of studies that focus on gender issues (Datta, 2007; Demirbas & Demirkan, 2007) and power imbalance between teacher and students (Dutton, 1987) that are limited in their scope and, like in the case of Anthony’s paper, focus on the jury evaluations instead of the ongoing studio learning experience. Finally, other authors adopt a global criticism that covers much more than the design studio, instead focussing on design education in general (Friedman, 2012; Wang, 2010); but the overarching scope of these proposals is difficult to apply to our thesis.

Considering these criticisms, it appears that we are not in a position to either defend or attack the design studio setting given the scarcity of empirical studies. In fact, the default position could be to accept the design studio as an effective educational environment, considering the format’s history of practice. And in truth, this seems to be the current consensus, with most researchers taking the starting point that the design studio is the established heart of design education.

Nevertheless, there are arguments to be made against the studio as the preferred setting of design education. The most cogent is that successful learning is considerably dependent on the personal relationship between

teacher and student. A situation made worse by the fact that design studio teachers are often practitioners without pedagogical training. Moreover, a problematic result of the insufficient understanding of the teacher-student interaction is the lack of well argued, empirically based guidelines for design teachers to apply in their practice. There is hardly any information to guide a tutor when beginning to teach in the studio, other than – rather interestingly – the guidance of a more experienced colleague²⁴.

Another result of a less than thorough understanding of this topic is that there is an unstable use of terminology in the literature. Many terms are used interchangeably even though they mean different things²⁵. This issue is not going to be resolved with one thesis, nevertheless, throughout this thesis (and in the theoretical framework in particular) we will try to apply terms that have already been proposed by other authors. The rule is to make adjustments to the existing terminology when necessary instead of proposing a new set of different terms. This way, we hope to make connections to the ongoing debate(s) that take place in design research.

2.1.2 A theoretical framework for an empirical approach

The theoretical framework we present here is instrumental to the practical work we have conducted. We think that enough deduction and theoretical work already exists on the topic of the design studio; therefore, our aim was to carry out research which is complementary to the current body of research in that it contributes with an empirical approach. The theoretical framework reflects that aim and supports the observations and analysis of teachers and students in real educational contexts.

The thesis is based on empirical observations of teachers and students in the ordinary running of a studio session. The theoretical framework's purpose is to serve as a structure that can guide the analysis of the observations. Since this research is mostly empirical, the theoretical framework aims to clarify the conditions, features, and variables that frame the context of observation.

The primary objective of this research, as we presented in Chapter 1, is to describe how the educational process unfolds in the design studio. On that basis, we developed a model of the design studio setting that accurately describes its defining features regarding how they influence the teacher and student interaction. The object of study is the personal

²⁴ The author of this thesis began his tutoring practice in the design studio in parallel with the beginning of this research. Other than the guidance of other teachers, there was little in the literature that could help his day-to-day tutorials with design students.

²⁵ This is also not helpful to achieve a better understanding of the topic; some of the unclear terms are quite common such as 'crit' and 'review'.

interactions between teacher and student while working on a design project. Some of the questions that guided the development of the theoretical framework were: What factors influence this interaction? How does the teaching/learning process of design unfold? Are there different kinds of teacher–student interactions?

Each section of the theoretical framework summarises the findings in models, taxonomies, and diagrams. We worked on the literature review with the purpose of synthesising information and then structure it in a template of the design studio. Therefore, the chapter concludes with an overall model that supports the analysis of real context observations.

Below is the initial model that establishes the foundational structure that will be detailed as the chapter unfolds:

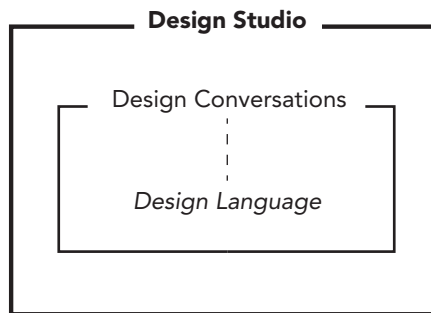


Figure 2: Design studio model (overview).

The model has three levels. From the broadest perspective, we have the design studio. From this point of view, we will explain and analyse the defining features of the design studio from the standpoint of how they influence design conversations. At this level, we deal with how the studio is structured, with a particular focus on the type of interactions that comprise it.

The next level is the actual teacher–student interaction (i.e. the design conversations). Here we will describe how the dynamics of the dialogue between teacher and student occur. In other words, we will describe the format of the interactions, what are the key features that characterise this conversation, and why the dialogue between teacher and student is the centre of the design studio.

Finally, the closest degree of analysis focuses our attention on the level of the content of the teacher–student dialogue. Here we will concentrate on the concept of design language, which allowed us to analyse the conversation in connection with the design process (of both teacher and student) and with the student’s design project.

The levels are connected and have an impact on each other, mainly from top to bottom. Any change to the fundamental constraints of the studio is expected to have consequences for the dialogue between teacher and student. Another way to look at the model is to consider that the highest level describes the macrostructure of the design studio and, accordingly, the microstructure includes both the format and content of teacher-student conversations.

In the final section of this chapter, we propose a general model of the design studio which includes definitions of the central concepts as well as several specific models that are linked. The initial model we presented above establishes the three primary levels of perspective; the levels also form the structure of this chapter itself. In other words, each level corresponds to one of the main sub-chapters of the theoretical framework, namely:

2.2 Design Studio

2.3 Design conversations

2.4 Design language

2.2 The design studio setting

2.2.1 The design studio – an overview of educational paradigms

The term ‘design studio’ evokes a familiar image to anyone that has ever visited a design school: an open-plan room filled with the sound of multiple conversations occurring at the same time. Ideally, there is plenty daylight from ample windows, individual drawing tables or desks are scattered in parallel lines, a U-shape, or sometimes randomly placed. The walls display an array of visual information: posters with presentations of previous projects, visual research posters, diagrams, inspirational boards, sketches, drawings, printed renderings, and photographs. In a study that was supported by field observations of design studios of an industrial course, Green (2005) summarised the studio’s overall configuration as “usually a large room equipped with drawing tables and chairs to enable students to work independently on projects. (p.10)

In a regular studio session, the students either sit and work on their projects, or wander the room, talk to each other, listen to music, and make the space their own. In the studio, each desk displays an arrangement of scattered papers, pencils, pens, experimental three-dimensional models, snacks, and a laptop or desk computer.

It would not be surprising for an outside observer to be unable to

distinguish, at first glance, the teacher from the students. Boling and Smith described the (2014) everyday role of studio teachers in the following manner:

The instructor spends the entire work period moving from one table to another confronting the problems that arise for each student designer as their projects take shape, and the critique period guiding discussion. Short, impromptu talks occur when a key principle comes up in the context of work, or when multiple students have reached a similar impasse or insight. (p.40)

Therefore, more often than not, the studio teacher can be found wandering from desk to desk, having short conversations, making comments, and occasionally sitting next to a student to conduct a more extended dialogue. This snapshot of the design studio is in sharp contrast to the traditional university lecture hall; the space differences between a lecture hall and design studio illustrate a paradigmatic difference in their underlying educational approach.

The typical university lecture takes place in an auditorium where the teacher stands in front of an audience of seated students. The spacial arrangement already suggests a different process of teaching and learning: in a lecture hall, the teacher is transmitting information while the students listen, take notes, and make the occasional question. In this setting, knowledge is transmitted from teacher to students, that is, the teacher knows something that can be clearly exposed to the students who then go on to demonstrate they have apprehended the content by taking an exam²⁶.

INSTRUCTIONISM VS CONSTRUCTIONISM

The lecture hall is the setting suited for the traditional paradigm of education known as *instructionism* (Sawyer, 2014) an environment where teachers mostly transmit information to students while students act as recipients of knowledge. The assessment takes the form of testing correct answers. Instructionism is a teacher-focused approach to education; this paradigm of education focusses on how knowledge transfer from the teacher to the student operates.

The counterpoint to the instructionist model (associated with traditional, lecture-based teaching) is constructivist learning. In this paradigm the learning is student-centric, that is, proponents of constructionism believe that a learner can actively construct new knowledge based on previous experiences. Johnson (2009) summarised both approaches as:

²⁶ There have been efforts to diversify the instructional mode of lecturing to accommodate more open-ended sessions (Johnson, 2009; Tangworakitthaworn, Gilbert, & Wills, 2011).

Instructionism refers to educational practices that are teacher-focused, skill-based, product-oriented, non-interactive, and highly prescribed. Constructivism refers to educational practices that are student-focused, meaning-based, process-oriented, interactive, and responsive to student interest. (p.2)

Of the two paradigms, constructivism is considered the underpinning of most contemporary research on learning theories, which may have led some authors to describe the design studio as a constructivist setting, (Kocadere & Ozgen, 2012; Kurt, 2009; Lester, Fitzgerald, & Stone, 1997; Waks, 1999).

CONSTRUCTIVISM AS A THEORY OF PEDAGOGY

The contemporary perspective on learning is that current learning theories have their foundations established in a constructivist theory of knowing. In the introduction to *The Cambridge Handbook of The Learning Sciences* Sawyer (2014) states that “the learning sciences are based on a foundation of Constructivism (...) learning sciences research has resulted in very specific findings about what support the learning environment must provide for learners to effectively construct their own knowledge.” (p.9)

Constructivism is, initially, a theory that proposes to explain how people know what they know. The fundamental notion is that people construct their knowledge using an active process in which direct experiences are built into and connected with what each person already knows. Therefore, the present view of learning is that people construct new knowledge and understandings based on what they already know and believe (Steffe & Gale, 1995).

Thus, constructivist educational theories view people as goal-directed individuals who actively seek information and knowledge. Additionally, when learners experience formal education, they do so with a range of prior knowledge that influences what they notice about the world and how they organise and interpret it. Moreover, it is this confrontation between environment and prior knowledge that affects people’s ability to memorise, reason, solve problems, and acquire new knowledge (Bransford, Brown, & Cocking, 2000).

The theory of constructivism originated from the work of three principal authors: Piaget, Vygotsky, and Dewey²⁷. However, in a review of the history of constructivism in education Steffe & Gale (1995) noted that the learning theories that evolved from the work of these authors blended into the broad approach that can be summarised by the core tenets: (1)

²⁷ We will discuss each author in detail further ahead.

students preferably learn by *doing* rather than *observing*, and (2) students bring prior knowledge to every learning situation. Moreover, Vygotsky's ideas, in particular, have evolved into ever more extreme versions of the notions originally proposed by the Soviet author. The detailed and careful articulation and empirical justification of his ideas diluted into the social-constructivist learning theories based on the overarching precept that *students construct their knowledge*. Furthermore, radical constructivists currently claim that "the function of cognition is adaptive and serves the subject's organisation of the experiential world, not the discovery of an objective ontological reality." (E. V Glasersfeld, 1988, p.83)²⁸

Two problems emerge from this theoretical standpoint: firstly, we infer that learning theories influenced by a radical constructivist point of view set up a subjective view of human knowledge (Phillips, 1995). In other words, it has become a staple of (radical) constructivism that there is no objective reality outside of what is socially constructed; which establishes the paradox of a worldview that is entirely relative to the individual's perspective while nonetheless being collectively constructed (Kukla, 2000). Secondly, the misunderstanding that teachers should never tell students anything directly but, instead, should always allow them to build knowledge for themselves. These misconceptions confuse a theory of *pedagogy* (teaching) with a theory of *knowing*. In fact, at first, constructivists assumed that all knowledge was constructed from the learner's previous knowledge, regardless of how one is taught. Therefore, even listening to a lecture is a personal experience that involves active attempts to construct new knowledge to a certain degree²⁹.

But were the ideas of the three originator authors this radical? The three authors (the contemporaries Piaget, Vygotsky, and Dewey) worked on different parts of the world and offered different perspectives on what are the determinant factors in the formation of knowledge. There was a theory of human knowing before being a theory of learning, that is, their primary concern and effort was to develop a theory of how people come to know what they know. In these endeavours, the three precursors of constructivism placed different emphasis on what were the defining factors determining human knowledge, and interestingly enough there was considerable overlap between their perspectives.

²⁸ See *Radical Constructivism: A Way of Knowing and Learning* (Glasersfeld, 1995).

²⁹ See Boghossian's (2006) *Fear of Knowledge: Against Relativism and Constructivism* and Kukla's (2000) *Social Constructivism and the Philosophy of Science* for a detailed critique of the social-constructivist paradigm.

CONSTRUCTIVISM AS A THEORY OF KNOWING

Piaget³⁰

The developmental work of Jean Piaget (1896–1980) is fundamental to establish the foundations of constructivism. Piaget described himself as a genetic epistemologist and developed his theory of learning from experimental studies with children. The Swiss author gathered that learning is a dynamic process that comprises successive stages of adaptation during which people actively construct knowledge by creating and experimenting with their theories of the world. According to Piaget, knowledge is not only acquired; instead, every person attempts to make sense of their environment by actively constructing their understanding of reality. This constructive process is not static (for Piaget, knowledge is neither static nor immutable) but ongoing “for the genetic epistemologist, knowledge results from continuous construction, since in each act of understanding, some degree of invention is involved (...) [knowledge] is always characterized by the formation of new structures which did not exist before, either in the external world or in the subject’s mind.” (Piaget, 1971) p.77

According to the Swiss psychologist, understanding the world implies an ongoing transformation of individual knowledge structures since “(...) human knowledge is essentially active. To know is to assimilate reality into systems of transformations. To know is to transform reality in order to understand how a certain state is brought about.” (1971, p.15)

Piaget proposes that knowledge is abstracted from human action and the coordination of these actions, and seldom from objects themselves. Piaget opposed the view of knowledge as a passive copy of reality. One only understands things in the world by performing an action upon them: “to my way of thinking, knowing an object does not mean copying it – it means acting upon it.” (1971, p.15)

Furthermore, Piaget rejected the distinction between abstract knowledge (logical and mathematical knowledge) and concrete or physical knowledge – i.e. knowledge based on experience. The Swiss argued that logical and mathematical knowledge can be abstracted from objects themselves (which is the empiricist view which holds, for the most part, for experimental or empirical knowledge) but crucially, that knowledge can also be abstracted from the actions themselves. For instance, when holding objects with different weights in one’s hand, one can realise that they have different weights and that often (though not always) more

³⁰ Jean Piaget (1896–1980) was born in Neuchâtel, Switzerland. He was a developmental psychologist, widely known for his theory of cognitive development, in which development is organised into a series of four sequential stages. (Dimitriadis & Kamberelis, 2006)

massive objects weight more than smaller ones, and so on, these are conclusions drawn experimentally, and the knowledge is abstracted from the objects themselves.

But on the other hand – to illustrate what is meant to extract knowledge from actions and not objects – Piaget offers the example of counting pebbles:

[H]e lined them up in a row, counted them from left to right, and got ten. Then (...) he counted them from right to left (...) and was astonished that he got ten again. He put the pebbles in a circle and counted them, and once again there were ten. (...) And no matter how he put the pebbles down, when he counted them, the number came to ten. He discovered here what is known in mathematics as commutativity that is, the sum is independent of the order. But how did he discover this? Is this commutativity a property of the pebbles? It is true that the pebbles, as it were, let him arrange them in various ways; he could not have done the same thing with drops of water. So in this sense there was a physical aspect to his knowledge. But the order was not in the pebbles; it was he, the subject, who put the pebbles in a line and then in a circle. Moreover, the sum was not in the pebbles themselves; it was he who united them. The knowledge that (...) [he] discovered that day was drawn, then, not from the physical properties of the pebbles, but from the actions that he carried out on the pebbles.” (pp.16-17)

Piaget went into some detail to describe the mechanisms whereby the interaction between information from the outside world and the pre-existing ideas of a person lead to the *construction* of new knowledge, which is incorporated into the individual's knowledge structures (*schemata*³¹ in the words of Piaget). The processes of assimilation and accommodation are crucial for Piaget's description of how individuals construct new knowledge from their experiences.

Thus, *assimilation* describes how personal experiences are incorporated into pre-existing understandings. The experience of the outside world is internalised without altering the structure of a person's pre-existing knowledge, in other words, new information is compatible with what one already knows and combines to form new knowledge, therefore building on a person's pre-existing ideas about the world. On the contrary, in the process of *accommodation*, events that conflict with pre-existing knowledge has to be accommodated into the mind, therefore changing

³¹ For Piaget, Schemata were the individual cognitive structures that described the environment and framed the person's reactions to experience. In other words, a schema is a set of linked mental representations of the world that people use to understand and respond to situations.

its organisation. Fundamental to both processes is Piaget's proposal that learning is a transformative rather than a cumulative process since learning is predicated on new ideas being integrated into the constantly adapting personal knowledge structures.

Therefore, Piaget's theory of learning describes how new information is shaped to fit with a person's pre-existing knowledge structures, which in turn are modified to accommodate the new information. In the author's words "knowledge, then, is a system of transformations that become progressively adequate." (p.15) In other words, we do not store knowledge as passive containers of information (like a hard disk drive accumulates information until it reaches its established limitation), instead, the accommodation of new knowledge actually transforms the organisation of the mind.

Vygotsky³²

In similar lines to Piaget, but with an emphasis on the role of social interaction, the ideas of the Soviet psychologist Lev Vygotsky's (1896–1934) are also foundational for constructivist learning theory. Presently, the author's social constructivist view is widespread in educational theory: "Despite his brief life, there is probably no major thinker, except perhaps Dewey, who has exerted more influence on educational research and practice than Lev Semenovich Vygotsky." (Dimitriadis & Kamberelis, 2006, p.198)

Vygotsky (1986) emphasised the role of language in cognitive development and in how people perceive the world. The author claimed that language provides the frameworks through which people both experience and communicate reality. For the author, language is fundamentally a social phenomenon, which means that knowledge is not only constructed, it is *socially* constructed. This focus on the social aspect of knowing lead to Vygotsky's theory to be known as social constructivism.

Furthermore, the operational aspect that enacts Vygotsky's social constructivism is the notion that people gradually understand their experience and social activities by interacting with more competent others. This element of Vygotsky's theory is called the The Zone of Proximal Development³³, which can be described as the difference between what a person already knows and the potential that a person can reach under the guidance of either a teacher or in close collaboration with more experienced peers, in the author's words:

³² Lev Vygotsky (1896 – 1934) was a Soviet (Belarus) psychologist and the founder of a social-constructivist theory of human knowledge.

³³ Vygotsky's influential conception of the Zone of Proximal Development has since been expanded into the *situated approach* to learning (Lave & Wenger, 1991).

The zone of proximal development is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. (Vygotsky, 1978, p.86)

There are a few fundamental differences between Piaget and Vygotsky's theories. Piaget believed the individual is primary in the learning process, while Vygotsky believed that social life is the main factor in learning. As Dimitriadis and Kamberelis (2006) note, "Piaget grounded his developmental learning theory in the individual learner and positioned children as active, intelligent, creative constructors of their own knowledge structures" (p.170). In contrast, Vygotsky's idea of the Zone of Proximal Development (ZPD) means that learning greatly depends as much on social forces as individual resources. Vygotsky believed that if students were not improving academically, their instruction was inappropriate. This belief contradicts Piaget's reasoning that students that fail to learn beyond a certain extent may have "plateaued" in a specific developmental stage.

The main difference between Vygotsky and Piaget is that for Vygotsky development does not precede socialisation. According to the author, the development of a person's learning occurs first on a social level and later on the individual level. Therefore, knowledge is generated first between people and only afterwards internalised by the individual. For the Soviet author, all higher functions of cognition (such as logical reasoning, and the formation of concepts) emerge as relationships between individuals and are dependent on language. Piaget, on the other hand, argued that the individual's construction of mental schemas was crucial for the process of learning. More recently linguists have claimed (on the side of Piaget) for the presence of evolutionarily determined knowledge structures (schemas) in the human cognition that pre-exist and prepare for the learning of language (Chomsky, 1965; Pinker, 1994).

Thus, Piaget and Vygotsky differed on the role of language in knowing. Piaget (1971) explores the hypothesis that "the roots of logical thought are not to be found in language alone"(p.18) instead, language has a role of coordinating actions: "but are to be found more generally in the coordination of actions, which are the basis of reflective abstraction." (pp.18-19) Piaget's argument is derived from his work with children where he identified instances in which children derive logical conclusions from actions: "if indeed we find logical structures in the coordinations of actions in small children even before the development of language, we are not in a position to say that these logical structures are derived from language." (p.9)

In short, Piaget adopted a constructivist view that focused on the individual, while Vygotsky's approach focused on social interaction. The contrasting perspectives lead to the theories of Vygotsky and Piaget's often being compared³⁴ to each other and lead to the development of two constructivist paradigms: *cognitive constructivism* (inspired by Piaget) and *social constructivism* (based on Vygotsky).

Dewey³⁵

A contemporary of Vygotsky and Piaget, John Dewey (1859–1952), the American philosopher, argued that knowledge emerges when learners experience situations that have meaning and importance to them. Dewey proposed a pragmatic epistemological perspective explaining that human thought is fundamentally a problem-solving matter that proceeds by testing hypotheses in practice.

Dewey rejected the notion that learning should be based on memorisation and repetition, and instead described a learning method where students engage with real-world problems where the learning context should enable students with the experience and opportunities to think for themselves. Thus, the author called for education to be grounded in real experience since, for Dewey, learning happens when students engage in sustained inquiry.

According to Dewey thought is not an innate staple of the mind, the author – in similar lines to Piaget³⁶ – proposed instead a *genetic epistemology* in which thought was viewed as the result of the interaction between a person and the environment. Dewey argues that the development of knowledge is a process of reaction and adaptation to the environment; the author defines environment as the “conditions [that] interact with personal needs, desires, purposes, and capacities to create the experience which is had” (Dewey, 1998, p. 44). Moreover, Dewey also posited that knowledge was fundamentally practical or instrumental – that is, developed to solve problems that human beings encountered in the world. This standpoint leads to Dewey to be associated with pragmatist philosophy (Festenstein, 1997).

Fundamental to Dewey's pragmatism is the role of *inquiry*. According to the author, inquiry includes three distinct phases: (a) the problematic situation, (b) identification of the parameters of the situation, and (c) reflection upon those parameters with the goal of generating a solution.

³⁴ Blake & Pope (2008), for instance, analysed and compared both theories in relation to their application in practice.

³⁵ John Dewey (1859 – 1952) was an American philosopher and psychologist.

³⁶ Both Piaget and Dewey ideas of a genetic epistemology were influenced by Darwin's work see (Messerly, 1996).

(Dewey, 1938; Dimitriadis & Kamberelis, 2006; Kaufmann, 1959). Therefore, his theory was closer to empiricism, in the sense that the author concedes that reality may to some degree be represented individually, but this representation is only true if it is effective in the context of the real-world. (Dimitriadis & Kamberelis, 2006).

Dewey's pragmatic perspective determines that education must be based on experience and not imposed given that "there is an intimate and necessary relation between the processes of actual experience and education" (1998, p. 20). The author argues that experience must be the centre of education. Similarly to what Piaget proposed, Dewey recognised that individual experiences build on previous experiences, and he insisted it is the teacher's responsibility to determine the direction in which an experience is heading.

Central to Dewey's perspective on inquiry is his unique understanding of the nature and functions of reflection. The American author was a significant influence on Donald Schön's theory of reflection-in-action³⁷. Dewey's definition of reflection was the "active, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusions toward which it tends" (1998, p. 9). For the author, reflection is a form of thinking "that consists in turning a subject over in the mind and giving it serious and consecutive consideration." (id) Dewey describes reflection as an alternative to an external restraint, for the author, reflection is a sort of individual inhibition made up of one's own reflection and judgment:

The alternative to externally imposed inhibition is inhibition through an individual's own reflection and judgment. The old phrase 'stop and think' is sound psychology. For thinking is stoppage of the immediate manifestation of impulse until that impulse has been brought into connection with other possible tendencies to action so that a more comprehensive and coherent plan of activity is formed. (1998, p.64)

Finally, for Dewey, learning meant primarily 'learning how to think', and "education consists in the formation of wide-awake, careful, thorough habits of thinking" (1998, p. 78). As such, the author was critical of education methods in which logically formulated, automatic information is transmitted to the student. On the contrary, Dewey valued educational environment in which thinking and reflection was paramount, especially reinforcing the "systematic care to safeguard the processes of thinking so that it is truly reflective" (1998, p. 85).

³⁷ In a paper (1992) Schön concluded "I believe that John Dewey, if he were alive today, would approve the sketch of educational research I have just proposed. But, of course, Dewey remains alive for us insofar as we are inspired to rethink and renew the meanings of the ideas he planted so long ago in the subsoil of our minds." (p.137)

A CONSTRUCTIVIST DESIGN STUDIO

The design studio can be described as an experience-based and hands-on approach to learning where students experience a simulation of a real-world problem. This description is consistent with what we have seen of Dewey's education philosophy that established the idea that learning occurs through experience and requires practical problem-solving and reflection. Dewey compares the experience of the learner to an explorer mapping a new territory (Dewey, 2004); the explorer (much like a designer setting out on a new project) does not know the terrain that lies ahead, he has to come across mountains, deserts, and uncharted waters and to overcome many hardships before his journey is over and the new territory is known. We can identify an echo of this idea in Schön's (1983) statement that design students do not know how to design until they do it themselves. To design is to set out on unknown territory. Knowledge is thus hard-won by engaging with a problem and experienced first psychologically and only later organised logically (in the case of Dewey's explorer, in the form of a new map; for a designer, in the form of a new artefact).

The process of learning is thus explorative, personal, and based on experience. Dewey's emphasis on exploration and the psychological importance of experiencing a new real-world problem is shared with Piaget's view that exploration is a requisite for the construction of personal knowledge. We have seen how Piaget describes learning as a process in which people construct an understanding of the world, identify inconsistencies between what they know and what they discover through experience, and adjust their ideas accordingly.

The design studio also has the necessary conditions to establish what we have seen Vygotsky describe as the Zone of Proximal Development³⁸. Consider a novice student's attempts to design while the more experienced design teacher offers guidance and support. Also, in the design studio, students will vary in their ability to design, which means that students also learn from each other in a similar dynamic to the one established with the teacher, but to a lesser degree since the knowledge difference between teacher and student is higher than between students. Nevertheless, Vygotsky's emphasis on the surrounding environment and the author's description of learning from the interaction with others is an apt description of the significant social component of the design studio classroom.

However, while constructivist ideas can be observed in the design studio,

³⁸ The difference between a learner's ability to perform a task without help and what he or she can do with the guidance of a more experienced person.

they are not a direct influence on its structure. In fact, the design studio setting was already established before the theory of constructivism was formulated; the studio setting emerged from the necessity of training craftsmen in guilds (Sennett, 2008) and developed through the years without much change to its fundamental dynamics until it was adopted by universities as the preferred way to teach design students.

Thus, in the case of the design studio, the theory does not precede the practice. Constructivist theory is useful to situate the studio in a broad educational perspective, and, in that sense, we can recognise why the design studio is often described as a constructivist setting. However, constructivist learning theories can be equally applied to many disciplines, that is, they represent a particular set of conditions in which human learning can occur. However, surely there are differences between how a design student and a student training to become a doctor (for example) are taught; to better understand the particularities (Shulman, 2005) of the design studio educational setting we need to look at the particular ways in which its teaching is structured, which are distinctive enough to be associated only with learning in design and therefore better described in its own terms.

2.2.2 Design Studio – A Coherent Educational Setting

OVERVIEW

The design studio model of education has common characteristics that are applied universally across design disciplines (Lawson, 2005). In this section, we will identify these essential features and try to describe the structure of the design studio setting.

The term *design studio* describes two things: (1) a physical space where students practice designing under the supervision of a teacher and (2) an educational model, in other words, an idea of how the teaching/learning process of design unfolds. Describing the studio setting, Cennamo and Brandt (2012) observed that the “[s]tudio, as traditionally applied in design fields such as architecture, industrial design, graphics arts, and the like, is simultaneously, a class, a space, and a pedagogical method of instruction.” (p.840)

Regarding the physical space; the studio is the place where students gather and work under the supervision of a design teacher. The academic design studios try to be a simulation of their professional counterparts. Moreover, the studio is the space where students spend much of their time during a design course (Ibrahim & Utaberta, 2012). Project work in a design studio takes up most of the time of a design course, as well as carrying more weight in the overall evaluation of the students. The

students are therefore expected to spend most of their time in the studio working on their projects.

Goldschmidt, Hochman, and Dafni, (2010) summarise the setting as:

The studio is a working space, but also a group of students who undertake design exercises, or projects as they are usually called, typically during one semester at a time, under the guidance of teachers (...) who are experienced designers but only rarely expert educators. A studio class typically meets two or three times a week for a number of hours, during which students present and discuss their work in progress with their teachers and sometimes also with classmates and guests. (p.285)

The design studio is a dynamic setting, where each student is responsible for the management of their own time and the development of each one's project. The self-reliance of the students makes the activity that goes on in the design studio somewhat unpredictable. Design studio sessions are often quite long (usually three or four hours) and only apparently unstructured.

The studio's educational process is a form of learning by doing in which design students spend most of their time working on design projects (Findeli, 2001). In a review of the literature of undergraduate design education, Lee (2009) concluded that "projects are assumed as the structure through which practice-based design education occurs (p.541).

Therefore, in a design studio class there are no exams; instead, the studio's activity is mostly based on project work. The studio sessions are arranged to answer a project briefing, and during the studio sessions, students are meant to work on a design project under the guidance of a teacher. Thus, the stages of the project structure the sequence of design work. Furthermore, a design project can often take up a whole semester:

Each student spends an entire semester working on a project based on an open-ended problem. During the semester the student's understanding of the problem becomes more and more complex, so their response to the problem is adjusted accordingly, usually several times. Critiques of each student's project are ongoing, and they are provided by instructors, peers and visiting experts. (Wang, 2010, p.176)

It is not merely the case that design students engage in projects. In the previous chapter, we concluded that a design project is a particular type of project that mostly deals with ill-defined problems (and even when the problem is stable and defined, designers tend to reformulate it and make it ill-defined). Green (2005) analysed the type of project typical of an industrial design setting and concluded:

The studio approach to teaching and learning differs from the dominant models of professional knowledge that apply in science and engineering, which are based on the premise that a collection of principles, rules and methods, can be applied to the solving of rational problems. (p.36)

As such, the design studio model of education is closely connected to the practice of design. In fact, the ways of thinking in design, (design thinking) and the process of teaching this way of thinking (the learning of how to design) form a coherent system (Shaffer, 2007). Ledewitz (1985) argues that the architectural studio³⁹ has three defined pedagogical objectives: to teach new skills, to teach a new language and to teach students to think architecturally. In other words, the praxis (design activity) epistemology (designerly ways of knowing [Cross, 2007]) and pedagogy (learning how to design) of design are adapted to each other. Uluoglu (2000) suggests that “the most important premise in teaching design is to let the student understand that design is a conscious activity (praxis), a practice of a skill or art which requires the specific knowledge of that field. (p.57)

The emphasis on practical learning means that the design studio assessment in the design studio exists in a formative-evaluative continuum. That is to say, learning and evaluation happen simultaneously and across time (usually a whole semester). This is different from a lecture-based class where the moments of learning and evaluation are distinct and clearly defined – i.e. a student attends a series of lectures and is tested at the end of the semester. On the contrary, in the design studio, the teacher attends to the development of the student’s work, accompanying the process step-by-step, following the student’s progress from session to session until she hands in a project and presents it to the class and often to a jury made up of university teachers. This process is often interspaced with intermediate deliverables that precede the final review.

The structure of the design studio setting can be summarised as:

(1) There is a fluid organisation of time and space; (2) the studio sessions are organised progressively according to the stages of the design project; and (3) feedback from the design teacher takes the form of one-on-one interactions (the design conversations) that leads to a final public presentations of the project to peers and faculty.

Therefore, the design studio setting cannot be directly adopted to teach another activity since there are defining features in the studio’s functioning that are firmly connected to design practice, after all, the

³⁹ Perhaps because it is the oldest established form of ‘design’, most studies on the design studio setting come from the domain of *architecture*.

design studio is the setting in which design students are initiated into professional practice. Observers that are outsiders to design disciplines might understandably fail to grasp how the educational system of design is structured; reflecting on this topic, Dinham (1989) suggests that “[c]onceptions of teaching proposed by traditional theorists outside architecture have long been insufficient to explain the subtleties of studio teaching.” (p.82) and in a discussion about design education in general, Wang (2010) stated that the design studio is a system of “complex interactivities [sic] involving multiple variables and agents – the apparent chaos of the architectural studio to those viewing it from outside.” (p.175)

The crucial focus of our investigation is the teacher-student one on one interactions, which we call design conversations; teacher and student one-on-one dialogue seems to occupy the central place of the design studio setting. Goldshmidt et al. (2010) stated that “[t]he design studio has been, and will probably continue to be, the cornerstone of design education. Its major feature is the one-on-one desk critique (crit), in which student and teacher discuss the student’s work in progress on a regular and frequent basis.” (p.285)

ONE ON ONE INTERACTIONS – OR, DESIGN CONVERSATIONS

In a series of studies, Donald Schön (1983, 1984, 1985, 1988; Schön & Wiggins, 1992) addressed how the one-on-one interaction between teacher and student unfolds in the design studio. The author describes the process as an apprenticeship, a dialogue that takes place in a simulation of real design practice; a shared ‘virtual world’ that the student explores under the supervision of the teacher. We termed these moments of interaction ‘design conversations’.

During the tutorials with the teacher, the student learns the language of design practice by engaging in design moves. The teacher models this behaviour for the student by “spinning out a web of moves, consequences, implications, appreciations, and further moves” (Schön, 1983, p.117). These moves create a network of linked decisions and experiments that feed and propel the project forward: “[e]ach move has consequences described and evaluated in terms drawn from one or more design domains. Each has implications binding on later moves. And each creates new problems to be described and solved.” (p.117)

Schön’s description focuses on teacher performance as an example of reflection in action. But Schön’s analysis of teacher-student dialogue also highlights the challenges and various roles that the teacher has to adopt during the interaction. The teacher alternates the role of guide, teacher, expert (Goldschmidt et al., 2010), and even design partner. The dialogue is an experience of practising how to design, that is, how to speak, how to

act, and what to do while designing while being guided by the teacher. On the other hand, the teacher tries to disclose the student's process, in an effort to understand how she is thinking.

The hallmark of this interaction is that teacher and student *design together*. Cossentino (2002) observed that “[o]ften, in the course of considering various design choices, student and teacher may ‘design together’. Designing together may involve the teacher sketching directly on the student’s drawing (...) a series of potential design solutions.” (p.43)

Notice how *design conversations* momentarily turn teacher and student into design partners. Here we have the heart of the teaching/learning process in design; the moments when the student describes her work and the teacher engages in conversation, suggests possible design solutions, draws, and makes suggestions on how to proceed with the design. The close tutorial is the moment when learning *how to design* occurs:

Both teacher and student demonstrate, reflect and discuss the design-in-progress throughout the process of instruction, and it is through this process of demonstration, reflection, and discussion that the student learns how to design as well as how to think about designing
(Cossentino, 2002, pp.43-44)

The iterative dynamic provides the student with a rich experience, which leads Ellmers (2014) to conclude that a reflective conversation “fosters [knowledge] transfer by supporting students to connect their thinking from the project with thinking about approaches to projects in the future” (p.32)

2.2.3 Types of design conversations

How can we characterise the teacher and student interactions that take place in the design studio? Are there different types of such exchanges? If so, what makes them different?

In this section, we will look into these questions, examine the known terminology, and propose a taxonomy of teacher-student interactions in the design studio. Considering its dynamic nature, it would not be surprising if an outsider were to find the design studio as an unstructured educational setting. However, this would be a misguided point of view. While the daily dynamic of the studio is fluid, the studio’s activity is in fact integrated within the structure of the project at hand – with its stages unfolding along milestone moments – as well as in a spectrum of progressively formal review sessions. Which is to say, there is an underlying structural thread to the seemingly disorderly activity of the studio.

A MODEL OF TEACHER AND STUDENT EXCHANGES

One of the first researchers that proposed a model of teacher-student exchanges was Dinham (1987a); the author begins by distinguishing between a) *instructional planning*, which tries to ‘establish the goals, expectations, general procedure, and assessment criteria (employed) for the project’ and b) *teacher and student exchanges*, meaning: implementing the project assignment through many kinds of teacher/student exchanges. In other words, point a) is concerned with the overall pedagogical approach to the studio course, whereas b) refers to the actual day-to-day teaching and learning that unfolds in the classroom itself.

Our research is concerned with b) *teacher and student exchanges*. Dinham proceeds to structure teacher-student exchanges with the following model:

STUDENT-TEACHER EXCHANGES			
Teaching in the studio		Teaching in reviews	
Individual desk crits	Groups	Interim reviews	Final reviews

Table 4: Model of student-teacher exchanges (Dinham, 1987a)

According to Dinham, there is a clear separation between teaching in studio and teaching in reviews. This distinction is confusing because reviews also take place in the studio; the author is trying to distinguish between the everyday teaching that occurs between a design teacher and his students (which she calls “teaching in the studio”) and the formal evaluation moments termed “teaching in reviews”. We find the use of the term “teaching in the studio” misleading. Even though reviews are fundamentally different from crits, they can – and often do – nevertheless take place in the context of the studio. That is, using these terms can lead to the misunderstanding that reviews are disconnected from the design studio activity, which is not the case at all.

Nevertheless, let us examine Dinham’s terminology. Beginning with the category of reviews, we notice it is further divided into *interim reviews*:

Interim reviews occur one to three times during the course of the project – sometimes by preannouncement and sometimes unannounced. In an interim review the crit calls the students together and takes them into a room whose walls are lined in tackboard. Students pin up their work-in-progress, and the crit moves from one to the next, commenting on the individual student’s work and summarizing the lessons for the entire group to learn from the example at hand. (p.7)

And *final reviews* (or “juries”) during which

The students' work is displayed for a panel of reviewers (principally local faculty, occasionally supplemented by local practitioners or guest faculty) who hear students in turn give oral introductions and explanations of their thinking and products, and who then provides criticism of both. Usually final reviews are public events: other students are expected to attend and to learn from reviews of their peers' work. (id.)

Notice that reviews are somewhat formal and evaluative events that take place in the context of the whole class. Furthermore, while the teacher is still present, the emphasis is not on individual teacher-student exchanges but rather on presenting and defending one's work (particularly during the final review) and the teacher tends to generalise aspects of individual projects for the benefit of the whole class.

On the contrary, what Dinham calls *teaching in the studio* has a fundamentally different character: here, be it individual or small group meetings, the exchanges are more private, and their character is informal. Of the two categories of teaching in the studio (individual and group crits,) the author suggests we should turn our attention to the *individual desk crit*, as the crucial moment of design education.

Thus, Dinham states that the individual desk crit is the fundamental category of teacher and student exchanges: "(...) desk crits form the core of the educational experience for students as well as the bulk of teacher contact hours." incidentally, desk crits are "(...) a much more private and less easily captured set of events.'(p.9) Which might explain Dinham's observation that (until that moment) despite its importance "desk crit teaching has been entirely unresearched" (id).

THE DESK CRIT

The term *desk crit*⁴⁰ repeatedly appears in design studio research literature, Dinham (1987a) describes it as:

[A] brief event occurring repeatedly through an afternoon. Typical the critic moves through the studio on a random or sometimes an informal "appointment" basis, meeting with students at their desks and discussing their thinking, their work, their progress, and their problems with the project assignment." (p.5)

Goldschmidt et. al (2010) describes the *crit* along similar lines and also state that it is the most important type of teacher and student communication in the design studio: "Its major feature is the one-on-one

⁴⁰ The term *crit* originates in the architecture education tradition and describes the short, individual, and informal meetings between teacher and student in the design studio.

desk critique (crit), in which student and teacher discuss the student's work in progress on a regular and frequent basis." (p.285)

These kinds of meetings are the most common events that occur in the design studio and focus on the development of the student's work.

(...) typically lasts between 15 and 30 min and takes place at the student's desk in the studio. The student begins by reporting the state of the project and describes its development since the previous crit. The teacher may ask for clarifications, and the ensuing discussion is meant to help the student make progress in the desirable direction. In this way students are meant to 'learn by doing.' (Goldschmidt et al., 2010, p.285)

Mewburn (2012) places the desk crit as the core of the design studio:

The pedagogical core of the design studio is the 'desk crit', a collaborative activity where the teacher and the student do design work together, discussing and sketching possibilities and imagining the consequences of design choices. During desk crit interactions the design teacher works to understand what the student is trying to do with his or her design work, provides feedback on these ideas and works with the student to further develop them. (p.364)

Goldschmidt et al. (2010) are careful to distinguish between a crit and a review, pointing to the differences regarding the formality of the interaction: "The discussions are at times formal (in which case they are referred to as reviews or juries) but most of the time rather informal." (p.284)

According to this perspective, *crit* and *review* (or *jury*) are distinguished according to their formality: a *crit* is an informal (or at least less formal) teacher and student one-on-one meeting, whereas a *review* is a more formal event. Another difference between a *crit* and a *review* is that a *review* takes place at predetermined moments of project development, normally corresponding to key moments of the design process, to which the students have to present predetermined deliverables:

A second distinction then is apparent between one to one crits in the 'studio' and the desk crit data examined. Here, students meet with their instructor at key decision points in their design process, the crits are particular milestones in progressing with the design work. The instructor reminds the students of the purposes of each meeting and what progression outcomes are necessary at the end. (McDonnell, 2014, p.7)

So, while there are common aspects between a desk⁴¹crit and a desk review these terms are not synonyms since there are a couple of significant differences between the two: (1) the review is a more formal event; this is the case because the reviews take place in predetermined stages of the project and therefore serve as milestones of the project's development and (2) the dialogue is more formative in a crit than a review (which is more evaluative) and (3) during a desk review the student is expected to present a specific set of deliverables (such as sketches, detailed drawings, or models), whereas in a crit a students may submit their work by way of sketches and models, but there are no specific deliverables expected.

For example, in a product design studio class, a first review usually takes place after a couple of weeks of the project's start; the students are then expected to present their initial ideas generally in the form of sketches. Therefore, the goal of a review is predetermined, that is, there are objectives that must be accomplished for the project to progress. Like McDonnell (2014) observed, this aspect renders the review more evaluative than a crit but without completely losing its formative dimension:

[W]hilst the meetings help students to shape their ideas (formatively), they also play a summative role, not as formal assessment points per se, but to mark critical transitions between phases of the design process the students are following.” (Mcdonnell, 2014, p.7)

On the other hand, a desk crit, while being a form of assessment, is nevertheless more informal, without pre-established results or objectives other than the teacher acknowledging the development of the project since the last meeting.

The student begins by reporting the state of the project and describes its development since the previous crit. The teacher may ask for clarifications, and the ensuing discussion is meant to help the student make progress in the desirable direction. (Goldschmidt, 2010, p. 285)

A crit is, therefore, a form of ongoing assessment, spread out through the many sessions of a studio class. While the term 'crit' is used extensively in the literature (particularly in architecture education research), its meaning is not consistent across the literature. For instance, Schön (1983) actually inverts the purposes of *crit* and *review*.

At the end of the semester, there will be a “crit” at which the students present their designs to Quist and to a group of outside critics

⁴¹ The term *desk* should be interpreted in a broad sense; it stands for the notion that teacher and student individual meetings occur in a working environment, be it the teacher's or student's desk.

(the “jury”). At intervals throughout the semester Quist holds design reviews with each student, and it is just such a review which Quist, in our protocol, conducts with Petra. (p.101)

Terminological inconsistency is perhaps unsurprising given the lack of studies concerning the topic of design studio instruction. In the next section, we will summarise the information gathered in this review in a model of design conversations. The model is based on the work that Oh, Ishizaki, Gross, and Yi-Luen (2013) did on a taxonomy of teacher-student interaction.

A TAXONOMY FOR TEACHER-STUDENT INTERACTION

Oh et al. (2013) developed a general theoretical framework of design critiquing; as a part of their work, the authors examined several dimensions of studio activity, which included a taxonomy that offers a comprehensive account of teacher-student interactions⁴² and provides a valuable foundation for the study of design instruction in the studio.

The authors propose a categorisation (the figure below) divided in four different settings (desk crit, group crit, interim review, and formal review), which are in turn characterised according to three perspectives: (1) number of students, (2) public/private, and (3) informal/formal.

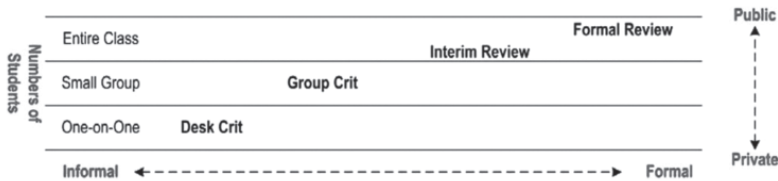


Figure 3: Oh, et al. (2013) model of teacher-student interactions

The taxonomy presents four critique settings.⁴³ As shown in the figure above, we can consider these settings from the perspective of the number of students, as well as the public/private, and informal/formal axis. The model is an invaluable contribution to the research on the design studio setting. The combination of the three perspectives creates a ‘map’ that

⁴² The authors named it *critiquing* settings.

⁴³ We should note that there is an a priori condition which is the distinction between individual and group assignments; that is, in this framework, each student is working on an individual assignment to which the crits, reviews, and group crits apply. In other words, the model does not include instances of group work. Accordingly, the axis that corresponds to the number of students refers to the number of students present during an individual critiquing event; so for example, a ‘group crit’ is not an instance of a teacher critiquing a group assignment, but rather individual critiques of a single student’s work, which takes place in the context of a small group of students.

charts the intricate context of design studio teacher–student interactions. Oh et al.’s work provides an indispensable framework to anyone attempting to understand and describe this educational setting.

However, while being a valuable blueprint of the design studio, Oh et al.’s model is not entirely adequate as a frame to observe and describe teacher–student exchanges. In our view, the model’s insufficiencies are connected to how the authors interpret the design studio interactions as a *critiquing* process:

We can describe what happens during critiquing as a sequence of steps or a process model. When a student explains his or her design work by showing the studio instructor drawings and physical models, the instructor listens and observes what the student has presented (observation). Upon noticing problematic and promising aspects of the student’s work (noticing), the instructor must clearly identify the issues and why they are problematic or promising based on understanding the immediate learning goals (identification). (Oh et al., 2013, p.316)

In our view, this critiquing process might be an accurate description⁴⁴ of some of the interactions — namely the reviews, which are closer to the formal end of the spectrum — but we argue that to place the critiquing process at the centre of the theoretical framework is misleading.

The emphasis on *critiquing* as the central form of teacher feedback is frequent and perhaps even predominant in design research (Dannels & Martin, 2008; Swann, 2002; Uluoglu, 2000; Utaberta et al., 2011). However, we find the term *critiquing* too formal; when we approach the informal end of the spectrum of interactions this formal aspect fades and loses relevance.⁴⁵ It is entirely possible that ‘critique’ is being used in a broader sense, but this is never explicit and unequivocally stated. Therefore, we think the description of the interaction benefits from a terminological clarification.

This conception of teacher feedback primarily as a form of critique, while somewhat predominant, is not wholly consensual. For instance, Schön’s (1983) description of the teacher and student interaction is much closer to a ‘working dialogue’ than the rigid critiquing–response–critiquing process the authors propose; what emerges from Schön’s observations of design

⁴⁴ The authors claim that the model is not meant to be prescriptive, but the description of the critiquing process entails that the teacher acts in a specific and prescribed way: “(...) the instructor must clearly identify the issues and why they are problematic or promising based on understanding the immediate learning goals(...)”

⁴⁵ Perhaps this is the reason why most researchers chose the diminutive ‘crit,’ immediately the word is rendered softer, less formal, and more open to the broader range of conversation that seems to prevail in informal teacher–student dialogue.

studio activity is that teacher and student engage in a reflective inquiry into the situation in which both are simultaneously engaging with the project at hand.

In several studies Goldschmidt (1991, 2002, 2011) also describes a different process while calling the interaction a 'crit', the author places sketching, and sketches, at the centre stage of the interaction, and goes on to describe the interaction in similar form to Schön, that is, as a working dialogue between the teacher and the student.

These views are closer to what we observed as being the predominant mode of teacher-student interaction in the case studies we present⁴⁶ (in chapter 3.) More often than not, the teacher engages in spontaneous, private, and informal working conversations with the students. These conversations varied in length but were mostly short span interactions. What we also gathered was that these short span interactions could form a sequence, in which the student builds on each conversation, and the project develops and changes.

This mode of interaction implies that the teacher performs a wider variety of actions than *assessment* and *critique*; we repeatedly observed several of the teachers in the case studies drawing, showing examples of precedents, suggesting alternatives, ideas, and solutions, engaging directly with student's models and drawings, explaining features of the design process, and so on.

In these tutorials the interaction grows in learning potential (Marda, 1996; Uluoglu, 2000). These are spontaneous moments that do not have predetermined outcomes (such as, for instance, a review, in which the student is supposed to present specific deliverables) it means the interaction is closer to a professional practice, where a senior designer might work together with a junior one. Under these conditions, the learning-by-doing occurs in its most elaborate way; it is in the simulation of professional practice that the student learns by proximity with someone who is more knowledgeable and experienced⁴⁷. This mode of interaction is characterised by a complex dialogue in which the studio tutor is teaching the student the language of practice in an applied way, by talking about it in connection with the student's project.

Thus, we propose the denomination of *desk tutorial* to describe those design conversations that are skewed towards the informal side of the spectrum and that can occur at any moment in a studio class. The

⁴⁶ As was explained in the methodological approach (chapter 1) we conducted observations of studio sessions as we were carrying out the literature review, the observations of teachers in practice influenced our analysis of the published theory.

⁴⁷ See Vygotsky's zone of proximal development (ZPD) (Vygotsky, 1986)

conversations in which teacher and student engage in a reciprocal *working dialogue*. That is, unlike a *crit* or a *review* the evaluative aspect is diminished, or even absent; instead, teacher and student work together on a specific part of the project, on a particular problem, or exploring a solution. It is expected, after a desk tutorial, that the student's project changes to a greater or lesser degree.

The notion of a desk tutorial implies that the teacher-student taxonomy needs a fourth axis with the opposites of formative – evaluative. The diagram below presents our proposed model of teacher-student interactions.⁴⁸

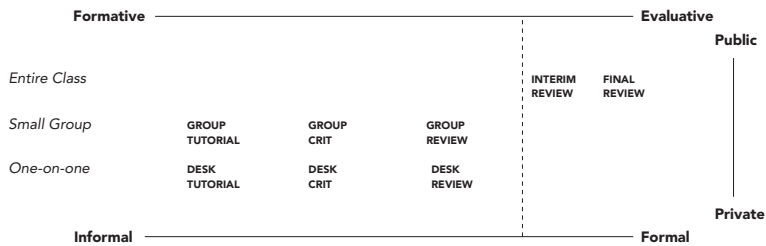


Figure 4: Taxonomy of design conversations.

The model functions like a map that places each type of design conversation along the axes; the teacher-student taxonomy of interactions is composed of eight categories:⁴⁹

	Desk tutorial	Desk crit	Review	Group tutorial	Group crit	Group review
Informal	Informal	Semi formal	Semi formal	Informal	Semi formal	Semif formal
When	Anytime	Anytime	Milestones	Anytime	Anytime	Milestones
Formative	Formative	Formative /evaluative	Evaluative/ formative	Formative	Formative/ evaluative	Evaluative / formative
Private	Private	Private	Semi-private	Semi-public	Semi-public	Semi-public
Individual	Individual	Individual	Individual	Small group	Small group	Small group
Deliverables	No	No	Yes	No	No	Yes

Table 5: Categories of design conversations

⁴⁸ This model is considerably based on Oh, et al's (2013) work.

⁴⁹ The model does not exclude the possibility of overlap between categories, particularly between tutorial, crit, and reviews.

Desk tutorial: can occur anytime during the unfolding of the project. A desk tutorial is an informal meeting started by either teacher or student during a design-studio session. It is a formative talk, in which there are no deliverables expected.

Desk crit: a desk crit is similar to a desk tutorial; the primary distinction between the two is that a tutorial can occur spontaneously and last only a few seconds; while a desk-crit is an expected meeting between teacher and student, which makes it slightly more formal and evaluative.

Desk review: a desk review is a scheduled meeting to assess the development of the student's project; it usually includes mandatory deliverables the student must present.

Group tutorial: the same conditions as a desk tutorial apply, but the interaction occurs within a small group of students.

Group crit: the teacher discusses the individual project of each student in front of a group of students. It is an opportunity for the students to learn from the feedback the teacher gives each student.

Group review: similar to a group crit, but in a group review the purpose is to assess the development of the student's project, which means the students are expected to present deliverables and sometimes prepare a presentation.

The final two categories are *interim* and *final reviews*. These are not examples of design conversations because they are not one-on-one interactions but rather presentations to an auditorium. Nevertheless, they mark the ending or an important milestone in the unfolding of the experience in the design studio, so we discuss them below.

Interim review: meetings held at milestones during the project; for example after a phase of analysis of the briefing. An interim review is a presentation to the entire class. These are not as formal as the final review, and the criticism tends to be more constructive than evaluative. The session can be public (open to guests) or private (just for the studio class).

Final review: held at the end of the project; may include a jury of outside critics (non-studio faculty members, other faculty teachers, and if there was a real client involved then a representative of the client's brand or company might be present). The students prepare a presentation that can include models, prototypes, panels, and a digital presentation that describes their design. Both the presentation and jury critiques are held publicly.

At the formal final review, students usually prepare a large panel where they arrange the key drawings that describe their designs. Students present their drawings and physical models as the jury moves from one student to the next, commenting on each work publicly. Jurors are sometimes asked to fill in an evaluation form for each student, which is later given to the students along with the studio instructor's assessment of their performance over the semester.

2.3 Design Conversations

2.3.1 Introduction

In this section, we will describe the format of design conversations. Design conversations are the instances of one-on-one dialogue between a teacher and a student while presenting, reviewing, or working on a design project. But how do we distinguish the countless spontaneous conversations that occur in the design studio from a design conversation?

Some characteristics differentiate a design conversation from other types of dialogue in the design studio, as well as from talks that take place in different (non-design) educational settings. A design conversation is made up of a series of elements that work together and influence each other. The interaction between these factors creates a dynamic that is particular to teacher-student exchanges in a design studio. We will now describe how this dynamic is set up and analyse its essential features.

2.3.2 Directed dialogue

The basic format of a design conversation is a dialogue⁵⁰ between teacher and student directed towards exploration of the student's design project. Whether it is a spontaneous meeting during an everyday studio session or a more formal review aimed at examining the project's overall state of development, the student's project is *always* the topic of a design conversation. This situation has a decisive impact on the unfolding of the teacher-student meeting.

A design project, even in an educational setting, is an exercise of design practice. Schön (1983) describes a design project as a sort of "case", that is, the units which make up a practice, and from a repeated experience of

50 In a design conversation the communication is not unidirectional; an example of one-way communication could be, for instance, if a student gives a presentation in which there is no immediate feedback from the teacher, or the presentation does not trigger a discussion. Similarly, we are not faced with a design conversation when the teacher presents a lecture in the studio.

many projects (or cases) a designer “develops a repertoire of expectations, images, and techniques. He learns what to look for and how to respond to what he finds.” (p.79) These experiences determine the development of a *knowing-in-practice* that “tends to become increasingly tacit, spontaneous, and automatic, thereby conferring upon him and his clients the benefits of specialization.” (p80)

In an educational setting, a design project is a simulation of this professional design practice, a virtual setting where the student engages with the practical role of being a designer. An educational design project can be very close to a professional experience⁵¹ in the cases when advanced students work with a real client. But regardless of project type, the crucial feature of a design project is that it is open-ended since designing deals with ill-defined problems. Discussing the pedagogical role of projects in the design studio, Kuhn (2001) stated that “[s]tudent work is organised primarily into semester-long projects, responding to a complex and open-ended assignment” and the author further adds that during project work the students are “permitted very broad latitude in their approaches” (p.349). Considering that the project is the centre of a design conversation, it follows that teacher-student dialogue will also be open-ended and therefore of unpredictable outcome.

A design project functions as the anchor that grounds the teacher and student attention in a working dialogue. A design conversation entails a back-and-forth personal interaction between the participants, an explorative dialogue that does not have a predetermined duration or a clear outcome. Because it is concentrated on the student’s project, the dialogue requires a degree of indeterminacy. There is no obvious outcome to a design conversation, and even a review may unfold in unexpected directions.

Thus, the project focusses the participants’ attention and engages both teacher and student in a practical conversation. That is, while theoretical aspects may emerge and be discussed, these are contingent to the unfolding of a particular project. Addressing the issues that emerge during design reviews, Oak (2000) argued that teacher and student often attend to issues that extend the project at hand. While the conversation is anchored on the project, the discussion can often go beyond that and confront the practice of design itself and the nature of design education.

51 Gjengedal (2000) described the basic categories of design projects, which Lee (2009) elaborated and expanded upon; both authors basically establish three types of project: (1) basic projects which are designed to help students learn project skills, these types of project often limit the student’s context of intervention, that is, they are designed in order to let the student experience a specific part of the design process; (2) guided projects, which are simulations of professional design experiences that require an active exploration on the part of the student (these are the typical projects in a design studio educational setting); and (3) authentic projects developed for external clients.

The author points out that during a conversation there are explicit and implicit levels of language, the former refers to the actual project being discussed while the latter connects with ongoing debates about design and design education.

Oak highlighted a few moments when the teachers were clear about specific behaviours or actions that professional designers often assume. These included several moments when the realities of manufacturing or a consideration of client needs clashed with the personal choices of the student-designer. The examples reveal how the teacher-student conversation starts grounded on the project at hand but inevitably connects to the broader context of professional design practice, leading the author to state that “in design education critiques, the students hear about what is likely and unlikely in the world of professional design.” (p.91)

In the study, Oak found some instances of these conflicting issues played out during the dialogue, and the author reaches an insightful conclusion: “face-to-face conversational assessment, with its explicit and implicit levels of information helps to promote a situation whereby those who already roughly comprehend the demands of design and design education, end up further comprehending, while those who don’t easily understand, or who are not engaged or confident enough to enquire, are left further behind.” (p.93) A similar point to what Schön (1987) described as the predicament of design education: that students come into the design studio without knowing how to design and are introduced to it by a process of trial-and-error through the tutorship of a teacher.

The discussion of a project establishes that the dialogue applies to a concrete situation, which sometimes leads the participants (more often the teacher) to alternate speaking with sketching or model-making. This situation further adds to the unpredictability of a design conversation. Not only are the participants working with the visual representations the student had done before the meeting, but also engaging with new representations that emerge during the dialogue.

This indeterminacy does not have to be provoked. On the contrary, it is the natural outcome of the interplay between teacher and student and the nature of working on a design project. Teacher and student are engaged in a practical conversation that deals with an ill-defined design situation, the student’s ideas express a temporary balance between the project’s constraints and the student’s proposed solutions to tackle them. In other words, problem and solution co-evolve in a progressive manner (Dorst, 2010), a proposed solution may have an effect on the situation’s constraints and lead to altering them, and likewise, a reformulation of a constraint may result in a satisfactory design solution. As we have seen in chapter 1, the establishment of a momentary problem-solution balance

has often been described in the literature as *framing* (Dorst, 2010; Lawson, 2005; Schön, 1983).

Crucially, new frames may emerge from the unfolding of a design conversation because the set up of a design conversation is conducive to an explorative and open-ended talk. Teacher and student engage with the materials of the design situation (expressed in visual design representations, i.e. drawings, models, and so on), and the interaction between these three elements (teacher – visual design representation – student) can result in a reformulation of the premises established at the beginning of the conversation. For instance, the teacher can disclose in a sketch something that the student did not perceive; this reinterpretation can result in a design move that leads to reformulate the understanding of the project. Likewise, it is often the case that teachers sketch during design conversations, in these instances the visual representations are created as the conversation unfolds; these sketches can in turn trigger insights in both the student and the teacher.

An entirely explorative conversation usually takes place in earlier stages of the project⁵², but given the unstable nature of the design project, the dialogue can always potentially result in a new understanding of the design situation. Even a review towards the end of a project may result in a design move or a redesign with implications for the final stages of the project.

The crucial element in the interplay between teacher, student, and the design project is the use of visual design representations (VDRs). We will see how these representations have a multi-faceted impact on teacher-student dialogue, and settle the dialogue in a practical engagement with the materials of the design situation. We will now look at VDRs in more detail, explain what they are, and what their role is in the design process.

2.3.3 Visual design representations

The crucial element that establishes design conversations as a unique form of learning-by-doing is the role of visual design representations as mediating artefacts of the teacher-student dialogue. As we will see, VDRs have a central place in the dynamic of teacher-student dialogue. But let us begin by describing what VDRs are.

Visual design representations are the forms of representation of a design

⁵² As we have seen in the previous section, this exploratory nature varies according to project stage and the formative-evaluative axis. Some conversations are pointed towards an overall consideration of the project, while others are focussed on details and sorting out of solutions and ideas. Thus, the indeterminacy of the dialogue varies with the type of conversation: for instance, a final review will not be as unexpected, and neither will it unfold as spontaneously as an initial tutorial.

situation used by designers while working on a project. In practical terms, visual design representations are the sketches, drawings, physical and virtual models, diagrams, and any other form of visual representation that designers use to express, communicate, explore, and examine any part of a design situation. Lawson (2005) succinctly describes VDRs as the “ways of representing design situations.” (p.293).

Visual design representations stand in the place of something else, in other words, they express an idea, a solution, detail, a problem, or whatever the designer needs to perceive, explore, or understand in a particular moment. The definition of design proposed by Schön (1983) is particularly useful here; the author states that “[a] designer makes things. Sometimes he makes the final product; more often, he makes a representation — a plan, program, or image — of an artifact to be constructed by others.” (p.99) Goldschmidt (1991) adds that designing “entails generating, transforming, and refining images of different aspects of that still non-existent artifact and making representations of it which enable communication and examination of the ideas involved. The ultimate objective of the process of designing is the production of visual representations of the designed entity with enough completion and coherence to allow its construction.” (p.125).

Therefore, VDRs are representations of the parts and the whole (the coherent relationship established between parts) of an artefact that does not yet exist. *Artefact* is a useful term in design because it can describe any designed entity. Erlhoff & Marshall (2008) defined artefact as any “object that is the product of human skill and ingenuity” (p.27). The purpose of design disciplines is to create artefacts of multiple kinds, as the authors state “usually understood to refer to a material object, artefact can also refer to designed spaces, images, software, systems, or environments where these act as coherent units.” (p.28)

For the production of an artefact to be possible, a designer generates many representations with increasing detail and refinement. Therefore the creation of visual representations is intrinsic to designing; developing visual representations of a *yet-to-exist* artefact has been described as ‘modelling’⁵³.

2.3.4 Modelling

Designing is the conception, evaluation, and communication of artefacts

⁵³ We are using the concept of *modelling* proposed by Roberts, Archer, & Baynes (1992) and later used by Cross (2001). In this section we concentrate on the activity of modelling, that is, modelling as the activity of creating both mental and concrete visual representations of a design. However, the authors also apply the term quite broadly to signify a language; we will address the concept of modelling as a kind of language in the next section: ‘2.3 Design Language’.

(concrete or virtual objects and systems) that do not yet exist. Since it is impossible to create each solution in detail and experiment with it, in reality, designers develop models to explore and test ideas effectively. These models take many forms but usually are variations of visual representations (sketches, drawings, and concrete and virtual mock-ups).

In design, this activity is often called modelling. Archer (1992) defined a model as “anything which represents anything else for informational, experimental, evaluative or communication purposes” (p. 7). This definition captures the notion of a model as a representation of something else and enumerates a series of purposes that models should fulfil. But is there a direct link between the model and the thing it represents? In other words, is a model a precise representation of the thing it represents? In the case of design, this question is particularly important because the thing being represented is *thought*.

Archer, Roberts, & Baynes (1992) propose a twofold conception of modelling that distinguishes between *cognitive modelling* and *concrete modelling*. Cognitive modelling describes the generation and manipulation of ideas in the mind’s eye, while concrete modelling is their externalisation in a specific form (such as a drawing). Archer (1992) elaborates on the idea of cognitive modelling as “the basic process by which the human mind construes sense experience to build a coherent conception of external reality and constructs further conceptions of memory and imagination.” (p.6) The author states that while cognitive modelling is independent of language or symbol systems, that is, it is conceptual, the images of thought can be “externalised through models and simulations, such as drawings, diagrams, mock-ups, prototypes and, of course, where appropriate, language and notation (...) [t]hese externalisations capture and make communicable the concepts modelled.” (p.4), the externalisation of the ideas in the form of visual representations is what the author calls concrete modelling.

The crucial point is that these two aspects (cognitive and concrete modelling) do not occur separately, the act of externalising an idea is an integral part of working out what the idea is. Otherwise, drawing from imagination would be the same as drawing from real-life observation, that is, copying of mental-images to the paper. In fact, as a designer thinks, he forms images in his mind’s eye, these constitute ideas that are manipulated and evaluated before, during, and after being externalised (through sketching, drawing, construction, acting out and so on).

The notion of modelling as a relationship between cognitive activity and concrete expression finds grounding in Arnheim’s (1997) theory of visual thinking. The author’s main thesis is that thinking can exist independently of (verbal) language; according to Arnheim, there is a

link between perception and thinking, and furthermore, perception is in itself an intelligent act. The essential point that Arnheim proposes is to “re-establish the unity of perception and thought” for that, the author provides an argument that clarifies the integration of perceptual and cognitive processes, introducing the notion that visual perception essentially involves thinking. This point is crucial for designing because it establishes a link between the ideas in the designer’s mind’s eye (the thinking) and the perception of their representation on paper, in fact, perception cannot be separated from thinking. In Arnheim’s words:

Cognitive operations called thinking are not the privilege of mental processes above and beyond perception but the essential ingredients of perception itself. I am referring to such operations as active exploration, selection, grasping of essentials, simplification, abstraction, analysis and synthesis, completion, correction, comparison, problem-solving, as well as combining, separating, putting in context. (id, p.13)

Moreover, perceiving includes the understanding of relation, how objects exist in context and in which way they relate to each other, also, when perceiving the mind is abstracting because “[a]bstraction, is the indispensable link and indeed the most essential common trait of perceiving and thinking” (id, p.188). Accordingly, we can say that, in line with Arnheim, perception is not a passive recording of stimulus material but an active concern of the mind, “(...) I see no way of withholding the name of ‘thinking’ from what goes on in perception. No thought processes seem to exist that cannot be found to operate, at least in principle, in perception. Visual perception is visual thinking.” (id, p.14)

A sketch, for instance, cannot be a direct representation of thought any more than words can, Arnheim (1993) states that “[m]ental images derive from optical percepts, but they are not identical copies of them” (p.15). Therefore, the designer sketches not only to try to capture these illusive thought-images but also to work through them to make sense of his thinking, so that we can say that thinking of an image and representing it are mutually reinforcing activities. Goldschmidt (1991) sums up this point when saying: “[s]ketching, then, is not merely an act of representation of a reformulated image; in the context we deal with, it is, more often than not, a search for such an image” (p.131). Thus, we conclude that visual design representations are a not only a medium to communicate ideas to others, but fundamentally are a tool to think, and nowhere is this situation more evident than when analysing sketching.

2.3.5 Sketching

Sketching occupies a special place in design and is considered a particular

kind of visual design representation. Cross (2007) states that in design, sketching (just like writing for most people) is a kind of intelligence amplifier, in fact, the author establishes a direct connection between sketching and design thinking: “without drawing, it is difficult for designers to explore and resolve their thoughts (...) [sketching] enables and promotes the kinds of thinking that are relevant to the particular cognitive tasks of design thinking.” (p.38) Lawson (2004) observes that designing is inextricably connected with drawing and thus “the drawing seems a useful source of potential insight into the knowledge that designers use.” (p.31) And Jones (1970) goes as far as describing the design process as ‘design by drawing.’

Regardless of the importance we attribute to drawing in the process of design, the connection has often been made between sketching and (design) thinking. But do all types of drawings have this quality of connecting complex cognitive activity and visual representation? There are many types of drawings that fulfil different functions in the design process. Also, designers produce different kinds of drawings for various purposes, and each variety of drawing has its characteristics and aims.

Building on the work Fraser & Henmi⁵⁴ (1994) Lawson (2004) proposes a taxonomy of design drawings which include *instructional*, *consultation*, *diagrams*, and *calculation* drawings that are done either to solve or communicate a technical aspect or to communicate a specific part of the design to someone else (a client, user, or any other stakeholder in the project); *experiential* drawings which are not done in the context of a project, but instead are spontaneous record of ideas unrelated to any design, that can sometimes serve as basis for ideas for future projects; *visionary* or *fabulous* drawings which are a particular kind of *presentation* drawings, primarily a drawing used to communicate with clients in order to obtain an agreement or permission to proceed with the project, these frequently express the essence of the project with brevity and wit and are meant to impress (hence the term ‘fabulous’); and finally the *proposition* drawings, these lay at the heart of the design process because proposition drawings are drawings that designers use to explore design moves. Proposition drawings are, most often, what is meant with the term ‘sketches’.

The subtle distinctions between types of drawings are beyond the scope of this thesis, and may even be diluted in practice, as Lawson (2004) observed: “[a]n added complexity here is that although these types have distinguishable characteristics any one drawing may contain features of more than one type.” (p.34) What is important for our framework is to

⁵⁴ Working from an architectural perspective, Fraser and Henmi (1994) identified five types of drawings: referential, diagrams, design drawings, presentation, and visionary.

acknowledge that there is a difference between drawings (of any kind) that are done with the intent of presenting something to others and drawings done in private to pursue a line of thought while working through a design situation; what Lawson (2005) describes as drawings “done by the designer not to communicate with others but rather as part of the very thinking process itself which we call design.” (p.26)

These private drawings have the quality of being a part of the thinking process of the designer. The characteristic of being a private drawing is more important than the type of drawing per se. The critical aspect is that designers interact with these drawings in a conversational manner (Schön, 1983), from this point of view, any drawing (or a model) can be thought of as a short experiment where the designer conducts and explores design moves. Schön (1983) describes how a designer selects the appropriate media (type of drawing or model) to use according to the type of topic he is exploring. For instance, while a quick sketch is useful to grasp a global idea, a cross-sectional drawing may be more adequate to examine other details, scale drawings enable the testing of dimensions, and mock-ups can be used to explore volume and structural issues.

Nevertheless, while any private drawing can be understood as an expression of the designer’s thought processes, sketches (proposition drawings [Lawson, 2004]) are more ambiguous, less determinate, and quicker to do, and therefore sketches facilitate a spontaneous consideration of ideas.

The close relationship between design thinking and sketching has been observed in several studies. For instance, Purcell & Gero (1998) suggested that the significance of drawing in design lied in the way in which sketching facilitated the reinterpretation of imagery; Tversky (1999) considers sketching as an integral part of the dialogue the designer conducts with himself during designing, from observations of the activity of designers the author concluded that sketching is “a cognitive tool developed to facilitate information processing. Drawings differ from images in that they reflect conceptualizations, not perceptions, of reality.”(p.2) Suwa, Gero, & Purcell (1998) concluded that besides being good ways to serve as memory enhancers, that is, as a way to leave ideas on the side to be examined later, sketches also “serve as a physical setting in which functional thoughts are constructed on the fly in a situated way.” (p.1048), and Kavakli, Suwa, Gero, & Purcell (1999) observed a correlation between visual reasoning and expert designer performance; Finally, Kavakli (in a study with Scrivener & Ball [1998]) suggested that “there is an intimate relationship between the cognitive and perceptual processes that are brought to bear on the recall and design tasks and idea sketching.” (p.485) therefore adding weight to the link between cognitive activity and sketching.

Employing the term 'conceptual sketches' to describe sketches (in the sense of personal drawings done in private) Menezes (2006) also confirmed that sketches are different "from any other type of drawings employed by designers in that designers create them not just to record an idea, but to help generate it." (p.571) A conclusion shared with Suwa, Gero, & Purcell (2006) that refer to 'unexpected discoveries' to which sketching seems to contribute a valuable impetus.

Regarding the connection between thinking and sketching, Goldschmidt (1991) was one of the first authors to call attention to the cognitive processes involved while sketching; the author presented a case where reasoning was observed to be associated with sketching during design:

(...) it is proposed that sketching introduces a special kind of dialectics into design reasoning that is indeed rather unique. It hinges on interactive imagery, by a continuous production of displays pregnant with clues, for the purpose of visually reasoning not about something previously perceived, but about something to be composed, the yet nonexistent entity which is being designed. (p.140)

Goldschmidt observed a pattern she described as a dialectic argumentation. The author points out that, during sketching, designers alternate between two types of reasoning: one type (described as 'seeing-as') is based on analogical or metaphorical thought and deals with extracting new meanings from the sketch; while the other type ('seeing-that') concerns the outcome of this newly acquired interpretation of the sketch. The interplay pattern of pictorial reasoning "which displays regular shifts between two modalities of arguments, pertaining to both figural and nonfigural aspects of candidate forms at the time they are being generated, as part of the design search." (p.123)

Furthermore, in the same study, the author concluded that other visual representations do not reveal the same ability as sketching to elicit the dialectic process which seems to be crucial for design: "[w]hen working without sketching, or when generating abstract displays, such as diagrams or flow charts, visual thinking takes place and the same reasoning modalities come into play. However, they are not organised in the dialectical pattern we have unveiled, at least not for any length of time." (p.140)

Later, Goldschmidt (2003) reinforced the special role of sketches in the design process when compared with other visual representations: "[t]he special role of sketches in design processes is distinguishable from the role of other images and visual displays that are used to support the design process. Designers make sketches because the sketch is an extension of mental imagery, and therefore has the freedom of imagery to retrieve previously stored images and to manipulate them rapidly." (P88)

Goldschmidt's studies reinforce the crucial idea that “[s]ketching, then, is not merely an act of representation of a reformulated image; in the context we deal with, it is, more often than not, a search for such an image” (id, p.131) Arnheim (1993), reacting to Goldschmidt's study, underlined this insight and stated that the dialectic process “does not take place between the drawing and the mental image but rather between the goal image and its realization” (p17).

Goldschmidt (1994) expanded on the notion of the dialectical process of sketching that occurs between mental imagery and sketches as a systematic exchange between conceptual and figural arguments; the author argues that designers often use sketching to “generate images of forms in their minds. (...) we assert that interactive imagery through sketching is a rational mode of reasoning, characterized by systematic exchanges between conceptual and figural arguments.” (p.158)

Arnheim (1993) emphasised that sketching is not merely a representation of the designer's mind, but instead, sketching is a kind of reasoning that “consists rather in a dialectic process, the oscillation of arguments which brings about gradual transformation of images ending when the designer judges that sufficient coherence has been achieved.” (p.15)

To summarise the point, it seems clear that designers engage in sketching not only to record ideas but to create them, and crucially, sketching does not copy (visual) ideas from the mind but contribute to generating them. There is a link between what Roberts et al. (1992) call cognitive modelling and concrete modelling, that is, between thinking and representation, which can be bridged by sketching⁵⁵.

This understanding has a direct implication for the role of visual design representations (and in particular sketches) in design conversations. Sketches open the door for a disclosure of the student's (design) thinking. Reflecting on this issue, Arnheim reached the conclusion that “[a]lthough the sketch stands for a passing stage of the design process, it stops that process and makes the designer examine at leisure what has been done and in what direction the further work must proceed” (p.17); in this sense, a sketch is like a photograph of the student's design process, or a register

55 In 1992, when establishing the industrial design course in the Technical University of Lisbon, Faculty of Architecture, Daciano da Costa (1930 – 2005) developed the course's pedagogy around the idea that drawing should be at the core of design (Spencer, 2001). There could be no dissociation between drawing and the design process, not only as the trigger to externalise first ideas but also as a critical instrument while the project unfolds and alternatives are generated. Drawing has the role of connecting a 'mental-object' and a 'real-object'. From this perspective, drawing is neither just another tool nor is it only a technique to communicate, it is structural for designing. The act of drawing develops a particular way of seeing and understanding, drawing (or sketching) is, in this sense, much more a process than a tool; a process of analysis, critical thinking, synthesis and communication (Côte-Real, 2009).

of the development of the student's thinking.

2.3.6 A taxonomy of visual design representations

We will now turn our attention to an overview of visual design representations. Besides sketches, there are several VDRs that have different formats and goals, and serve various functions in the design process.

The work of Pei, Campbell, & Evans (2011) is here an indispensable source for our framework. The authors developed a taxonomy of visual design representations from a thorough review of sources that had hitherto remained dispersed. The authors propose a comprehensive model that includes an organisation of the most commonly used representations from product design to mechanical engineering. Their taxonomy is an invaluable resource for design research.

Pei et al. do not adopt a succinct definition of VDRs, instead opting to describe its many characteristics. Nevertheless, it is possible to summarise what the authors consider to be the essential aspects of VDRs from their descriptions of the concept. Thus, according to the authors, VDRs are externalisations⁵⁶ of design ideas that reproduce properties of a design proposal through physical and virtual means in the form of two-dimensional and three-dimensional media.

Pei et al. describe the purpose of VDRs in similar lines to what we found in the taxonomy of drawings of Lawson (2004) and Fraser & Henmi (1994). Thus, the purpose of VDRs include to visualise, communicate, and store information; to externalise thought or to function as a thinking tool; to verify decisions; to derive new design ideas; as an extension of short-term memory, and finally as a persuasive aid.

The first level of categorisation of the model establishes two main groups: two-dimensional and three-dimensional representations. Two-dimensional representations include sketches and drawings, while three-dimensional representations take in models and prototypes. These distinctions organise the main four groups of VDRs (figure below.)

⁵⁶ Notice that, according to Pei and his colleagues, VDRs are 'externalisations of ideas', which presupposes that the idea is already formed before being externalised in a visual medium. However, we have seen how in the case of sketching (at least) the activity of drawing is integral to the understanding of the idea itself. Nevertheless, the externalisation (what Archer [1992] called the concrete modelling) is undoubtedly one of the fundamental purposes of VDRs, and this definition does not prevent us from looking at the taxonomy of Pei et al. as an adequate structure to describe the goals of VDRs and their place in the design process.

VISUAL DESIGN REPRESENTATIONS			
Two-dimensional		Three-dimensional	
Sketches	Drawings	Models	Prototypes

Table 6: Taxonomy of Visual Design Representations (Pei et al., 2011)

The four main categories are described in the following manner:

Sketches: a sketch is a freehand drawing that presents a preliminary, rough representation of the design without much detail. It is executed swiftly and contains key elements of the design. This definition is sufficient to distinguish sketches from drawings, but we refer to the discussion we presented above for a more broad understanding of the role of sketching in design.

Drawings: a drawing takes a more formal arrangement that determines a particular form (closer to the artefact's real dimensions) and is structured to formalise and verify aspects of the design. Some drawings can follow disciplinary or industry conventions and are rigorously executed with either mechanical instruments or with the use of computers.

Models: models are employed to simulate the general functional properties of a design. Models permit the exploration of tangible aspects and allow designers to have a concrete experience of the function, performance and aesthetic aspects of the design.

Prototypes: prototypes serve to communicate and verify the final configuration and the functional elements of the artefact.

Sketches and models are better suited to the early stages of development for problem-solving and idea-generation, whereas drawings and prototypes are employed towards the later stages as a technical evaluation of the artefact's performance. Of course, like many aspects of designing, this is only a rule of thumb. In practice, there is often considerable overlap and, for instance, a prototype may be deployed at the beginning of the process and sketches and drawings are often used from early to later stages of the design process.

The authors then proceed by detailing the sub-categories of the main four types of VDR to describe their different purposes.

VISUAL DESIGN REPRESENTATIONS: SUB-CATEGORIES			
Sketches	Personal		
	Shared		
	Persuasive		
	Handover		
Drawings	Layout rendering		
	Scenario & storyboard		
	Presentation rendering		
	Perspective		
	Technical/Engineering	Diagram	
		General arrangement	
		Detail	
		Technical illustration	
		Sketch model	
	Models	Design development	
Operational			
Appearance			
Technical/Engineering		Functional	
		Assembly	
		Production	
		Service	
Prototypes		Appearance	
	Technical/Engineering	Pre-production prototypes	

Table 7: VDRs sub-categories (Pei et al. 2011) summarised

To summarise, visual design representations reproduce properties of a design proposal through physical or virtual means in the form of two-dimensional or three-dimensional media. These representations can be placed on a spectrum from early depictions of ideas (sketches) to highly technical descriptions of the final design (prototypes).

An important aspect emerges from this discussion of visual design representations: some VDRs are used to think, that is, they are personal explorations of design thinking done in private. These are usually done at the beginning of the design process and are bounded to a designer's *internal* cognitive activity. Other types of VDRs are used to communicate with others, that is, to persuade, to convince, or to solve technical problems, as such, these are pointed *externally*.

However, regardless of their internal or external purpose, visual design representations are always a description of an artefact that does not (yet) exist. This notion has implications for the role VDRs play during a design conversation.

MODELLING AN ARTEFACT THAT DOES NOT YET EXIST

Regardless of how detailed and finalised a representation is, there is no external reality to which a design representation can refer, because the process of design is meant to create representations of an artefact that does not yet exist. Creating the artefact is embedded in the process of representing it.

Therefore, any representation of an artefact also communicates aspects of the thinking processes involved in designing it. Even situations where a designer uses a drawing to communicate with others (to convince, or to work through a technical difficulty, or to express a particular aspect of the design) involve some consideration of what the final artefact should be.

Keeping that in mind, it is important, nonetheless, to acknowledge that there are degrees of indeterminacy in VDRs. A final design offers less space for reinterpretation than a sketch drawn in the early stages of the project. Furthermore, a drawing made to communicate with others also has rhetorical aims (i.e. it is often meant to convince of the adequacy of a design); whereas a personal sketch is free of these concerns and is, therefore, more vague, ambiguous, and indeterminate. It is an expression of work in progress, not meant to be judged on its aesthetic merits or technical rigour but instead used as a part of the process of thinking through a design situation.

Nevertheless, all drawings done during the design process have some of the quality of being a part of the thinking process of design. As such, any visual design representation of the student offers an opportunity for the teacher to explore the thought processes involved in its making. In short, the VDRs can reveal a part of the student's design process.

Davies and Elmer (2001) reached the same conclusion after conducting a case study to examine the role of modelling in design education with an emphasis on the connection that Archer (1979) proposed between cognitive and concrete modelling. The authors concluded that "modelling is at the core of design and technology capability and its external manifestation provides learners and their teachers with 'a concrete lever' that can expose and get a purchase on their thought processes. It is a tool to access meta-cognitive activity" (p.166)

Visual design representations are then a gateway to access the student's design process. Let us now consider the role of VDRs as the mediator in a

design conversation.

VISUAL DESIGN REPRESENTATIONS AS MEDIATING ARTEFACTS

In a design conversation, the visual design representations (of any type) have the role of mediating artefacts⁵⁷. The dialogue between teacher and student is decisively influenced by the representations the student brings to the discussion. The student's VDRs communicate the development of the project and also serve as a record of the evolution of her (design) thinking. Therefore, the purpose of a VDR is to make the project known and the design process understandable.

It is important to note that students bring VDRs to the meeting with the teacher which were done priorly in their homes or while working in the studio on their own. In other words, the student's thinking and modelling was done in private, and prior⁵⁸ to the meeting. Davies and Elmer reached an insightful conclusion regarding this issue: "if design and technology education seeks to give access to learners' thought processes then the trace of that thinking will be mostly captured in learners' concrete modelling and specifically in the modelling that has themselves as audience". (p.166) In other words, the thinking the student employed is embedded in the visual representations.

Schön also addressed this issue when stating that "the act of drawing can be rapid and spontaneous, but the residual traces are stable. The designer can examine them at leisure." (p.193) In other words, the visual design representations of a student leave a trace of the reasoning involved in their making, like a fossil record of the student's design process that the teacher must uncover.

Combining what the teacher perceives in the drawings (or other visual media) with what the student explains verbally, the teacher may be able to string together the student's line of thought, and thus reveal the underlining design process. This enables the teacher to provide feedback and guidance accordingly.

Therefore, the dynamic between teacher, student, and VDR, can be summarised as design students use modelling to express their ideas in visual representations, and in turn, the teachers examine them to disclose

⁵⁷ Mediating artefacts is a term used in the literature of learning theory (see Conole [2012] for an overview on the theme) based mainly on the work of Vygotsky (1978); it is important to state that we are using the term as it is defined in this thesis, that is, mediating artefacts as a means to convey the design project and to form a link between teacher and student and in the sense of making the student's project known and the design process understandable.

⁵⁸ Of course, the student can also think and design while talking with the teacher, but the thinking that is being presented in the VDRs was done previously.

the student's design process and assess the state of the project. Thus, the teacher may determine if the project is on the right path, if it has shortcomings, or if there are promising ideas to pursue. It also allows the teacher to examine the student's design process and provide advice accordingly. A series of sketches, drawings, and models may reveal a detailed picture of the student's process of design. Even a single sketch may disclose information about how a student perceives the design situation (is the student adopting an overview perspective? Or is she more concerned with details?)

In general, the role of visual design representations is to establish a concrete link between teacher and student and to convey aspects of the student's design process.

FRAMING

Another important aspect of the role visual design representations play in the dynamic between teacher and student is what Schön (1983) calls the construction of a shared 'virtual world'. During a design conversation, teacher and student are exploring representations of the design situation. These representations establish a temporary order that permits the participants to discuss the design without having to consider all aspects that form the complexity of the design situation.

In other words, a sketch, drawing, or a model present a cursory understanding of a complicated design situation. These momentary understandings (or *frames*) define a virtual setting shared by teacher and student. The participants can then explore and experiment within that defined frame. The process is efficient because it is quick and iterative since design situations can be framed and re-framed several times during a conversation. Lawson (2004) articulated why this framing process is a central feature of design thinking when saying "(...) it is often not possible to think about the totality of the problem or indeed the solution at all times. It simply is too complex and confusing a matter. Instead, designers seem to narrow their attention by setting up a situation, focusing, or 'framing'"(p.91).

These frames are seldom the result of objective analysis. Different designers looking at the same design situation or working in different stages of the design process will apply different frames of their own. The context of the design situation and the individual way of working of each designer will determine how the framing occurs. In a design conversation between teacher and student, it is expected that the teacher will do most of the framing.

While the process of modelling can be quick (particularly when sketching) the resulting representation can be examined for as long as necessary. A

sketch can be done in a few seconds but examined for hours. In a study of communication among design teams,⁵⁹ Goldschmidt (2007) described that an integral part of the dynamic of the interaction was that the participants shared 'mental models' of the design. According to the author "[r]epresentations in the form of rapid sketches serve as artifacts that represent the designed entity in its various phases of developments." (p.43) Goldschmidt reinforces the idea of sketches being the preferred means of developing visual representations, the pace at which a designer can generate a sketch makes it the most efficient medium to evoke mental models of artefacts.

Therefore, we gather that visual design representations are integral to the construction of a virtual world that teacher and student explore together (a shared mental model). The virtual setting that both participants share enables the participants to conduct short experiments. In other words, the visual design representations can be considered as the laboratory of the design project, a 'place' where design moves are enacted, examined, and explored. As Schön observed "[b]ecause the drawing reveals qualities and relations unimagined beforehand, moves can function as experiments" (p.193).

Establishing momentary limits to the ill-defined design situation (framing) and conducting small experiments (design moves) in the framed context is facilitated by visual design representations. VDRs encapsulate specific aspects of the design in a momentary frame. In turn, the boundaries defined by the frame render each element of the design visible; a frame is a point of view that enables the exploration of a design situation from a multitude of perspectives: including the examination of details, or the consideration of the whole, or even a complete reformulation of the design.

However, this process of framing (the creation of momentary shared virtual worlds between teacher and student) is not done solely through visual representations. Verbal language is fundamental to reinterpret the situation.

2.3.7 Design language

Which bring us to the final element of a design conversation: *design language*. The representation of a design situation does not occur only with visual media. It is a combination of modelling and talking.

The primary medium of communication that teacher and student employ during a design conversation is *talking*. In fact, both participants use

⁵⁹ We can, for a moment, consider the teacher-student pairing as a design team and the same logic applies.

verbal language to refer to the visual design representations (VDRs), that is, the VDRs may establish a frame, but words are fundamental to interpret it. Sketches are often ambiguous, their meaning embedded in the designer's thinking, the use of verbal explanations are crucial to decipher, explain, and translate their meaning to others.

Therefore, the language used to talk about the design is intrinsically connected to the visual representations of the design. The words are a translation of a visual medium to a verbal one. Since we saw that VDRs express the design (the concrete representations) but also have traces of the designing (the thought processes involved in creating the representations), then the words being spoken are critical to understanding the design conversation.

In a paper that reported on observations of student's designing, Cross (1996) described how a combination of drawing⁶⁰ and talk contributes to the unfolding of the design process. Cross particularly highlighted the role of words in bridging ideas and visual representations of the design.

A combination of words and visual representations give rise to a 'language of design'. Design language is primarily an expression of the design process, that is, it communicates aspects of the activity of designing. Furthermore, when used in combination with visual representations, words can also serve to frame the design situation. That is, words can have a complementary role to what is being represented in visual media and contribute to a detailed representation of the design. In this sense, the words spoken during a design conversation are simultaneously a description of designing and a part of it.

Design language serves as a common language between teacher and student. Both participants use it to discuss the project. We will elaborate on the language of design in the next chapter. For now, to complete the description of the format of design conversations, it suffices to acknowledge the role of design language as a common language between teacher and student.

2.3.8 Teacher and student dialogue – a common language

We conclude with the observation that teacher and student interaction can naturally be described as a kind of dialogue. This dialogue is infused with references to the project at hand, visual elements, form giving, and several other aspects. The combination of these elements constitutes what we will designate a language of design.

⁶⁰ 'Drawing' is often used in design research as a synonym of 'modelling', especially when used as a verb.

Crucially, this dialogue reveals aspects of design activity that would otherwise remain implicit. Unless when prompted to speak aloud – or when working with a team – when a designer designs he or she does so in silence, with even the dialogue with oneself that Schön (1983) describes occurring silently, internally in one's mind. Therefore, the design studio requires the teacher to make his thinking explicit.

The language of design is thus a type of discourse that is contingent upon the design studio setting; in other words, a design practitioner that is also a design teacher, has no reason to explain, express, or communicate his thoughts while designing and about designing unless he is in a design studio educational setting, sitting next to a student considering the project at hand.

Thus, the talking is a consequence of the teacher using the language to communicate with the student. The teacher is teaching the language while using it to build a bridge with the student. Therefore, the verbalisation is only present because the teacher needs to verbalise it to the students. Otherwise, the 'dialogue' would be internal, and only externalised by sketches.

In this dual process, the student is both learning and applying the language of designing as she learns it. The burden on the teacher is enormous; it is as if the teacher must help the student cross a river by building the bridge as they move along; which means he must be a step ahead lest the student fall.

2.3.9 Summary: design conversations model

The diagram below presents the design conversations model. The model describes the format of design conversations, and how it fits in the overall theoretical framework. The model can be summarised in the following manner:

The context of design conversations is the pedagogical and physical setting of the design studio. Design conversations take the format of a dialogue between teacher and student while presenting, reviewing, or working on a design project. The dialogue is mediated by visual design representations (VDRs) in the following manner: (1) VDRs are the 'material' with which both participants work during the interaction, (2) they reveal the stage of development of the student's project; (3) VDRs also disclose aspects of the student's thinking and design process; and (4) visual representations establish a shared virtual setting between teacher and student – a frame – which functions as a laboratory for experimentation (the design moves).

Visual design representations illustrate the design project's problems and

solutions by means of sketches, drawings, models, and prototypes. VDRs are also a record of the student's design thinking process. Therefore, an examination of the VDRs has the potential to reveal the student's thinking. In fact, using the VDRs as the mediator element of a conversation with the teacher results in disclosing aspects of the design process, since there is an interplay between drawing and talking which is integral to the design process, and the interaction between words and visual representations elicits design language.

Finally, the meetings between teacher and student are fundamentally a conversation where the participants play different roles. The teacher is the expert designer that guides the students in their attempts at designing, while the student is the novice that follows the teacher's example and explanations. So, the design studio format encourages the teacher to offer explanations, to make his thinking clear and visible to the student. The language of design is, therefore, a type of discourse that is a natural part of the design studio setting.

Thus we observe that the teacher-student dialogue is framed by a common language which is the language of design. A language that the teacher has mastered and the student is beginning to understand; this predicament shifts the balance of the interaction towards the teacher, who must help the students grasp this new language and, simultaneously, use it to communicate with them.

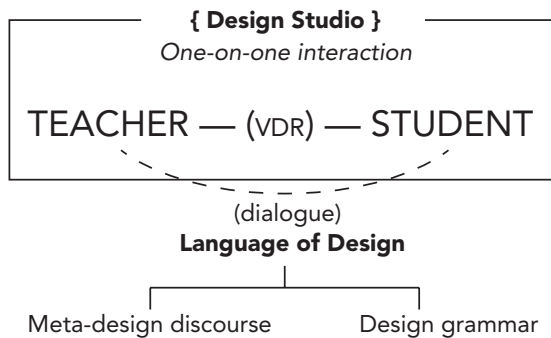


Figure 5: Format of design conversations.

2.4 The Language of Design

2.4.1 Introduction

In the previous chapter, we described the role of design language as a part

of the dynamic of a teacher-student dialogue in the design studio. In the model of the design studio we propose, the language of design is the focus of analysis of teacher-student interactions.

For this thesis, we define design language in the following manner:

Design language is the visual or verbal expression of the design process used by teacher or student during a design conversation. The language of design is a language of practice since a design conversation takes place in the context of working, presenting, or reviewing the student's project. The language of design is twofold; it can refer to elements of design (design grammar) or to the process of designing (meta-design discourse).

The concept of design language we adopted was first proposed by Schön (1983, 1987), and we naturally drew extensively from the author's description of the term. However, as Marda (1996) observed, describing the structure of design language and how it operated was never the primary focus of Schön's studies. The author defined it only sufficiently to be applicable to his theory of reflection in action. Therefore, the concept of design language requires detailing to be used as an operational concept of this research.

The language of design is embedded in the format of design conversations. If the design studio established the overall pedagogical context, and design conversations described the arrangement of teacher-student interaction, then the language of design model enables us to examine the content of the dialogue between teacher and student in the design studio.

2.4.2 The concept of design language

We expand on the concept of a language of design beyond a metaphorical interpretation. Previous research has suggested that designing involves a particular language that shapes a specific kind of thinking. From this point of view, the language of design can be understood as a general cognitive capacity shared by all. A form of thinking independent of a specific professional activity.

Nigel Cross (2007) proposed that design could be understood as a third area of human knowledge, on par with the sciences and the humanities; central to this notion is the idea that to each area of human knowledge corresponds a specific kind of language: Science (numerical), Humanities (verbal), and Design (nonverbal). The author positions Design (with a capital 'D') in the realm of material culture, a culture that "relies not so much on verbal, numerical and literary modes of thinking and communicating, but on nonverbal modes." (p.28)

Material culture is the medium where designers operate, since design is the activity that creates the artificial world, containing objects, technology,

and interaction with things, and it is also the domain of the everyday use of objects and their meaning (Krippendorff, 2006; Norman, 2013). This is the professional culture of designers, and it is this medium that informs their thinking, “designers are immersed in this material culture, and draw upon it as the primary source of their thinking. Designers have the ability both to ‘read’ and ‘write’ in this culture(…)” (Cross, 2007, p.26).

Cross states that design has been neglected as a third area of human knowledge, and suggests that its terms should be adequately named and articulated. Design, then, should be understood as the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing (Cross, 2007). This idea is founded on the previous theoretical proposals of Archer (1979), in which the author lamented that there was no word in English “equivalent to literacy and numeracy, meaning the ability to understand, appreciate and value those ideas which are expressed through the medium of making and doing.” (p.19) Archer also defined design broadly as the collected human experience of material culture, placing it side by side with Science and the Humanities as a third area of human activity.

Cross (2007) proceeds by comparing the sciences, the humanities, and design according to the phenomenon of study, methods of enquiry, and values of each of the three cultures (we summarised Cross’ comparison in the table below).

THREE CULTURES OF HUMAN KNOWLEDGE			
	Sciences	Humanities	Design
PHENOMENA OF STUDY	Natural world	Human experience	Artificial world
METHODS	Controlled experiment, classification, analysis.	Analogy, metaphor, evaluation.	Modelling, pattern-formation, synthesis.
VALUES	Objectivity, rationality, neutrality, truth.	Subjectivity, imagination, commitment, justice.	Practicality, ingenuity, empathy, appropriateness.

Table 8: Comparing the three cultures of human knowledge (Cross, 2007).

The author calls for design to have its own inner coherence, similarly to the other established areas of human endeavour, Cross seeks to identify the fundamental principles that structure design as an intellectually equivalent discipline to the sciences and humanities. According to the author, there are four main ideas that make design a unique culture and distinct area of human knowledge:

- (1) The central concern of design is the conception and realisation of new things;
- (2) design encompasses the appreciation of ‘material culture’ and the application of the arts of planning, inventing, making, and doing;
- (3) at the core of design is the language of ‘modelling’; it is possible to develop students’ aptitudes in this language, equivalent to aptitudes in the language of the sciences (numeracy) and the language of humanities (literacy); and finally,
- (4) design has its own distinct things to know, ways of knowing them, and ways of finding out about them.

One of the key aspects highlighted by Cross to establish design as a coherent area of human enquiry is its language. According to the author, modelling is the ‘language’ of design. Traditional model representations include the sketches and drawings of proposed design solutions. In the previous chapter, we concentrated on modelling as the activity of conceiving visual design representations. We will now discuss modelling as the language of design.

MODELLING

The notion of modelling as a language of design comes from the work of Archer (1979). The author proposes that “the way designers (...) form images in their mind’s eye, manipulating and evaluating ideas before, during and after externalising them, constitutes a cognitive system comparable with, but different from, the verbal language system.” (p.18) Archer is alluding to the idea of cognitive modelling we discussed in the previous chapter; for the author, cognitive modelling is as fundamental to thought and reasoning as is the human capacity for verbal language.

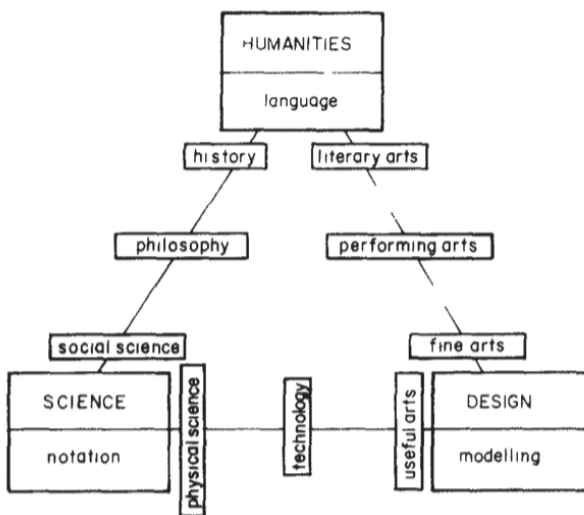


Figure 6: Design as a third area of human knowledge (Archer, 1979)

Previously, we concluded that the output of modelling were visual design representations; and what is more, the act of creating these representations (the *concrete* modelling) was integral to the formation of images in the mind's eye, in other words, *concrete* and *cognitive* modelling formed a dialectical system, both feeding on each other's output. Cross uses a different terminology and refers to representation as the manipulation of non-verbal codes "these codes translate 'messages' either way between concrete objects and abstract requirements; they facilitate the constructive, solution-focused thinking of the designer, in the same way that other (e.g. verbal and numerical) codes facilitate analytic, problem-focused thinking;" (Cross, 2007, p.27)

Therefore, cognitive modelling facilitates a constructive and solution-focused mode of thinking, which are basic ways of thinking in design. Similarly, as early as 1977, Eugene Ferguson (1916 – 2004), also suggested that the non-verbal aspects of thought were crucial elements of the creative thought of designers: "Much of the creative thought of the designers of our technological world is non-verbal, not easily reducible to words; its language is an object or a picture or a visual image in the mind." (Ferguson, 1977, p.835)

The American engineer also addressed the comparison between design (the author referred to design and technology in combination) and the natural sciences and the humanities: "[t]his intellectual component of technology, which is nonliterary and nonscientific, has been generally unnoticed because its origins lie in art and not in science." (id, p.835)

The output of modelling is the creation of visual representations of a design. Therefore, we can describe modelling as a visual language. Therefore, instead of defining the language of design as something it is not ('non-verbal'), we propose that the language of design – i.e. modelling – can be adequately described as a visual language.

THREE CULTURES OF HUMAN KNOWLEDGE			
	Sciences	Humanities	Design
LANGUAGE	Numerical	Verbal	Visual

Table 9: Comparing the language of three cultures of human knowledge.

But is design language only a visual language? Or are there verbal aspects embedded in the process of designing?

A VISUAL AND VERBAL DESIGN LANGUAGE

The comparison established in the table above suggests that designers are,

to a large extent, visual thinkers (Arnheim, 1997; Muller, 2001). However, the understanding of 'modelling' as the language of design is not sufficient to describe what designers do during the design process and the uses of language within that process.

As we saw earlier, typical design problems are ill-structured, which means the design process is fundamentally an explorative search for a design solution. The exploration part is essential because there is no "ideal" or unique project solution to a design problem, nor any algorithms that can be applied; such as, for example, in a chess problem that regardless of how complex it may be, has an optimal solution that can be derived within the initial limits established by the problem.

In design this is not possible, the constraints of a design problem are altered as the designer applies different frames in search for an adequate problem-solution pair. Also, design deals with the creation of artefacts (which means that the process of designing requires detailed visual representations so that its production is possible,) and the exploration is – to a large extent – a process of creation, re-creation, examination, and analysis of visual representations. While the initial process is explorative and somewhat unstructured, a designer, nevertheless, thinks things through during the process of generating, developing, and evaluating ideas. That is, the designer examines possible partial solutions, combines parts and whole to ensure their coherence, as well as their adjustment to the requirements and constraints of the problem. In other words, the designer reasons, and this reasoning is informed, in no small degree, by the visual representations of the design, which at the beginning of the process are mainly sketches.

From this point of view, there is a consensus that during the design process the designer is reasoning visually. The process requires that the ideas in question are visually represented so that they can be reacted to, reformulated, and refined or rejected. Especially when we consider the dialectical interplay between concrete and cognitive modelling it has become increasingly discernible (see the research of Goldschmidt [1991, 1994, 1995]; Purcell & Gero [1998]; Tversky [1999]; Suwa, Gero, & Purcell [1998] or Verstijnen et al. [1998]) that designers use visual representations and imagery to *think*.

It is clear that the human mind is cognitively equipped for visual imagination (Arnheim, 1997; Ware, 2008) and designers seem to use this capacity to good advantage when creating visual representations of the design. As we have seen, the visual representations then elicit further visual reasoning in a dialectical process of 'discovering' the (yet-to-exist) artefact.

However, when we consider the design process as a whole, then this conception is not sufficient to fully grasp the role of language in designing. The verbal dimension returns, and we are forced to consider a combination of visual and verbal dimensions to have a full picture of design language. Here, the work of Schön is again instrumental. The author (in the study quoted below working with Glenn Wiggins) reinforces the importance of words in the creation of meaning during designing:

In all this 'seeing', the designer not only visually registers information but also constructs its meaning – identifies patterns and gives them meanings beyond themselves. Words like 'recognize', 'detect', 'discover' and 'appreciate' denote variants of seeing, as do such terms as 'seeing that', 'seeing as' and 'seeing in'. ((Schön & Wiggins, 1992, p.135)

Visual design representations have an important role to play as external means of communication, that is, in the cases when the designer needs to explain a technical aspect of the design, or when trying to persuade a client of the adequacy of a solution,⁶¹ but even these visual representations benefit when complemented with words; furthermore, there is also the dialogue the designer has with himself while designing, in fact, designing can also be described as conversational:

A conversational interaction with the situation is taking place in which drawings and ideas each have their role. Ideas are undoubtedly processed through concepts described in words. These words have enormous significance since they represent a complex set of characteristics some of which may help the designer to see a way of proceeding. The drawings appear to reveal problems and enable the designer to see unsatisfactory situations. Together these two powerful forces combine to make the very essence of design thinking. (Lawson, 2005, p.270)

In a study conducted with design students, Avidan & Goldschmidt (2013) identified a correlation between a high final studio grade and students that combined visual and verbal language during their process. Similar results have suggested that verbal reasoning is advantageous for the design process (Cikis & Ek, 2010; Oak, 2011) but, like Lloyd, Lawson, & Scott (1995) observed, verbal language has a complementary role in the design

⁶¹ Concerning persuasion, Lawson (2004) describes an interesting example from one of the interviews he conducted with expert designers: "When British Rail wanted to develop a new design for their InterCity trains they invited a number of leading designers to submit proposals. The winners were in fact Seymour/Powell (...). The Seymour/Powell submission was not based on drawings or traditional design documents. They simply explained to British Rail that their design would be 'heroic' in the manner of the British Airways Concorde and that it would once again make children want to become train drivers as in early times. We can only imagine that such a description must have triggered childhood memories in the minds of some senior British Rail executives, and that they carried with them their own image of such a train." (p.86)

process, and words neither reveal nor elicit all design cognition.

It is also interesting to notice that in the structure of the design studio proposed in chapter 2.1, the interactions between teacher and student throughout the project are structured around a series of progressively more formal verbal discussions of the design project. The student begins by having a series of informal dialogues with the teacher (the desk tutorials) and goes through reviews and presentations where she must argue and reason about her project to her peers, to a jury, to a faculty panel and so on.

Therefore, we conclude that words are also a part of design thinking. In fact, words are likely to be significantly involved in all human thinking⁶² regardless of the discipline or specific occupation. To have a complete picture of design language, we must combine the visual reasoning described as *modelling* (Roberts, et al. 1992) which is the part of design language that deals with the creation of visual representations of an artefact, and explains how designers create and develop images in the mind's eye through a dialectic process between cognitive and concrete modelling; but also the self-referential (i.e. referring to both the project and the design process) verbal expressions that help to reformulate, interpret, frame, and expand the understanding of a design situation.

In short, verbal language and visual representation are both expressions of design thinking that interact with each other and have an impact on the design process.

2.4.3 Donald schön's language of design

The language of design, as Schön (1983) described it, entails a self-referential verbal and visual language. It describes a language of design that establishes a conversational dynamic between teacher and student but also between both participants and the visual representations of the design. Talking adds another layer of meaning to the design representations. The teacher can interrogate the student, but can also 'ask questions' or talk to the student's drawing, the teacher does not "describe what is already there on the paper but parallel the process by which he makes what is there." (p.102)

This 'talking to the drawing' is quite literal. In the descriptions of teacher-

⁶² Noam Chomsky's theory of Universal Grammar (Chomsky, 1965) argues that language is hard-wired into the brain and that there are common properties shared by all human languages. The author's thesis derives from the observation that there is a considerable gap between the linguistic stimuli that children experience and the linguistic knowledge they manage to develop. More recently, Steven Pinker (1994), arguing against the 'blank slate theory' (that is, that people are born without any biological determined linguistic structures) also argued that humans are born with an innate capacity for verbal language.

student interaction Schön observed the teacher saying, for instance:

“The kindergarten might go over here... then you might carry the gallery level through—and look down into here” (p.101)

“This is to scale? (...) what about north-south?” (p.105)

“Now in this direction, that being the gully and that the hill, that could then be the bridge, which might generate an upper level which could drop down two ways.” (p.108)

In the transcripts above, the teacher assigns functions to the design, details solutions, and investigates the student’s drawings using his verbal interjections to expand what the drawing represents, as well as by sketching himself while speaking. These observations lead Schön to describe design language as: “[d]rawing and talking are parallel ways of designing, and together make up what I will call the language of designing. The verbal and non-verbal dimensions are closely connected.” (p.102)

Therefore, design language is self-referential (the object of attention of design language is both the design and designing itself) and can have an impact on the design process. On the other hand, it is also a description, an expression, or a representation of the design process.

The language serves to reflect and also to reformulate the process, and it can contribute to reframing the design situation. A discussion of the design between teacher and student can have an impact on the design project, and change the approach to the design process. In other words, while designing, speaking can transform both the design concepts and the concept of designing.

Schön’s concept of design language includes and combines visual and a verbal dimension. It is a particularly useful framework for our research since our object of study is fundamentally a conversation, a dialogue between teacher and student. While the conversation may focus on concrete visual representations (drawings and models), the medium is inherently verbal.

It is this conception of language that we will use for our framework. We will now proceed to expand on the concept of design language proposed by Schön. This chapter will end with a model of the language of design which describes its essential features.

2.4.4 A language of design

The idea of a language of design that we present here is based on Schön’s proposal of a language of professional design practice (1983). The author defined it as:

The language of designing is a language for doing design, a language game which [the teacher] models for [the student], displaying for her the competences he would like her to acquire. But [the teacher's] discourse is also punctuated by parentheses in which he talks about designing. (p.102)

According to Schön, the language of designing is twofold: on the one hand it is a metalanguage in which the teacher is talking about the design process – the language *about* designing; on the other hand, the teacher also refers to specific *elements* of designing. The author describes the two categories of design language in the following manner:

a) Meta-language: “These are examples of a language about designing, a meta-language by means of which [the teacher] describes some features of the process he is demonstrating and with which he introduces [the student], however cursorily, to reflection on the action of designing” (p.103)

b) Elements of design: “Elements of the language of designing can be grouped into clusters (...) [t]hese design domains contain the names of elements, features, relations, and actions, and of norms used to evaluate problems, consequences, and implications. As he designs, [the teacher] draws on a repertoire of design domains to fulfil a variety of constructive, descriptive, and normative functions.” (p.119)

From this point onwards we are elaborating on what Schön proposed and expanding on his definitions. Schön defined design language only until it was useful for his investigation of the ideas of reflection-in-action. On the contrary, we are taking design language as a central concept for our thesis; as such, we need a more clear and stable definition and a clearer description of its features and overall structure.

Schön identified two categories of design language but offered tentative descriptions of each one. Therefore, we propose a slightly different terminology to describe each aspect of design language; and an initial understanding of the language of design as a kind of discourse that is twofold (see table below):

LANGUAGE OF DESIGN	
Meta-design discourse (MDD)	Design grammar (DG)
Reflection on the action of designing	Design domains
Reflection in the action of designing	Elements of design

Table 10: Language of design.

Let us now consider each of these two aspects in detail starting with design grammar.

2.4.5 Design grammar

DESIGN ELEMENTS

We adopted the term *design grammar* because, while language is a highly complex system of human communication, grammar presupposes a narrower focus on structure, rules, syntax and the combination of different elements to form a larger whole.

Therefore, we define design grammar as the design elements that constitute the parts of a design. In other words, design grammar can be understood as the elements used to design, that is, the parts and relationships between them, that are synthesised in the form⁶³(understood as a unified structure of parts) of an artefact.

Note that, 'design grammar' is not a synonym of 'design domains'. Design grammar is a verbal reference to a design element spoken during a review of a design project, that is, the reference is integrated in the context of discussing a design project. That is, design grammar is a part of design language, not a set of elements external to the context of the discourse.

Another way to understand it is: design elements are like musical notes; musical notes are always the same and only acquire musical expression when played within a musical piece. Furthermore, the same note acquires different senses, colourings, emotions, and significance when placed in a different sequence of chords or harmonic structure. A single note isolated from a musical context is meaningless. The same goes for design grammar categories which refer to the elements (the notes) that are combined in a specific design (the musical composition).

Design grammar is then a type of discourse that is contingent on the conversations that unfold during the act of designing, in other words, it is not separate from the context in which it is spoken.

DESIGN DOMAINS

As Schön stated, design elements can be clustered into domains. Let us take the example of the Eames lounge chair. The chair combines wood,

⁶³ It is important to distinguish between the idea of shape, which is the outline, contour or external surface of an object, and form. Form is a broader and harder to define concept. Arnheim (2004) adopted the formulation 'form is the visual shape of content' (p.96), thus proposing that form is a visual entity connected with the actual materialised shape of an object. According to Arnheim, form is a mental construct, employed when referring to essential (immaterial) qualities of an object, whereas shape is better used to describe an object's actual physical appearance.

leather, and metal to form its design. Wood, leather, and metal are design elements that can be clustered in the domain of *materials*; however, note that this categorisation is context dependent, so for instance, if we refer to how wood is moulded to form the shape of the back, then we are in the domain of *technology*.

We can refer to design domains independently and without the context of a design project, but in those cases, we are not talking about design grammar; for instance, if we consider a lecture about the general structural capabilities of plywood. It is a different case when we refer to the specific role plywood plays in the shaping of the chair's form. In the latter case, plywood takes on a more specific meaning (a more *designerly* meaning), because the technological aspects of plywood (its advantages and disadvantages as a design material) become interconnected with the product's overall aesthetic, function, contrast with other materials (in this case, leather) and so on.



Figure 7: Lounge Chair and Ottoman by Charles Eames (1955) Source: Wikipedia Commons

This is to say that there is no direct mapping of a list of design domains to a list of design grammar categories. It is the context of the design project that determines which design domains are relevant. Therefore, a description of design grammar categories should remain broad and be accommodating to different projects.

Design Grammar categories⁶⁴

To suggest a list of design grammar categories we take as a point of departure the general domains suggested in Schön's case study which are listed below:

DESIGN DOMAINS		
Domain	Definition	Context
Program	<i>Functions of building or components, uses and specifications.</i>	Extrinsic
Sitting	<i>Features elements, relations of the building site.</i>	Extrinsic
Building Elements	<i>Components of buildings.</i>	Intrinsic
Organisation of space	<i>Relations of spaces with one another.</i>	Intrinsic
Form	<i>Shape, geometry, organisation of space, experience of movement through space.</i>	Intrinsic
Structure /technology	<i>Structures, technologies, and processes used in buildings.</i>	Intrinsic
Scale	<i>Magnitudes of buildings and elements in relation to one another.</i>	Intrinsic
Building character	<i>Kind of building.</i>	Intrinsic
Precedent	<i>Reference to other kinds of buildings, styles, or architectural modes.</i>	Extrinsic
Representation	<i>Languages and notations by which elements of other domains are represented.</i>	Extrinsic
Explanation	<i>Context of interaction between designer and others.</i>	Extrinsic

Table 11: Language of design.

Schön's categories are influenced by the studio context he observed. The domains that the author enumerated are connected with typical architectural categories. It is expected that different design disciplines will reference different domains. We will alter Schön's list to make it more applicable to product design,⁶⁵ while aiming to keep the categorisation as

⁶⁴ A thorough discussion of some of the aspects we include in design domains would take several theses to accomplish: for instance 'form', 'function', or 'sustainability'. We provide a short description and assume the straightforward definition of these terms and take them in the sense of how they apply either to being a part of the form or the context of an artefact.

⁶⁵ It is important to clarify what we mean by 'product design'. This categorisation can be confusing because in practice the terms *industrial* and *product* design are often used interchangeably. This is unsurprising since both terms cover the same spectrum of

broad as possible.

A first analysis of the domains listed by Schön revealed that some of them correspond to intrinsic properties of the artefact while others are contextual. The column labelled 'context' is an addition we made to Schön's description that distinguishes between both. This distinction will be our first categorisation. Therefore, we propose that design grammar includes intrinsic and extrinsic elements:

Intrinsic elements are elements that the designer can control and directly contribute to the form of an artefact. These are related to the concrete form (the shape) of the artefact.

Extrinsic elements of an artefact are out of the direct control of the designer. That is, they refer to broader aspects such as social and cultural aspects, or history, but that can still influence the designer's decisions and the overall artefact configuration.

DESIGN GRAMMAR	
Domain	Sub-domain
	INTRINSIC
Form	Basic geometry
	Attributes
	Composition
Function	Purpose
	Usability
	Fruition
Materialisation	Materials
	Structure
	Operation
	Configuration
	System

object possibilities (for instance furniture, electronic appliances, or tableware.) However, contemporary design practice includes designers who – while following the same process and emphasis on reproducibility – tend not to work with mass-production of goods; instead, they focus on a more personalised approach to the design process, with more limited production quantities, while working closely with either craft-based workshops or small factories. Therefore, the term product design seems to capture a wider range of activity ranging from mass-production to lower production amounts.

DESIGN GRAMMAR	
Human-factors	Ergonomics
	User requirements
	Cost
	Sustainability
Communication	Connotation
	Denotation
EXTRINSIC	
Representation	
Program	
Context of use	
Artefact	Part
	Type
Precedent	

Table 12: Design Grammar categories.

The intrinsic elements include form, function, materialisation, human factors, and communication; while the extrinsic elements encompass: Representation, program, the context of use, artefact, and precedent. Let us now consider each category more closely.

I. Intrinsic elements

1. **Form**⁶⁶ is the visual shape of content (Arnheim, 2004). It is divided into three sub-categories.

- 1.1 **Basic geometry:** these are the primary geometric form generators (point, line and plane) the combination of these elements results in the creation of volume (positive and negative space), and fundamental geometric figures (regular solids such as a cube).
- 1.2 **Attributes of form:** texture, value (light-dark), type of shape (regular, angular, rounded) and colour.
- 1.3 **Composition:** concerns the aspects of composition, structure and spatial organisation. These principles address the visual relationships between different parts, between parts and whole, and further explores the transition between 2 and 3 dimensions.

2. **Function** is a crucial aspect of design, it means how well an artefact performs or executes its intended purposes. It is subdivided into:

⁶⁶ On the issue of form-giving in design we reviewed (Boucharenc, 2006; Hannah, 2002; Itten, 1975; Muller, 2001).

2.1 **Purpose:** what needs the artefact is intended to fulfil.

2.2 **Usability:** the ability to be used, how easy it is to use.

2.3 **Fruition:** in the sense of enjoyment, or of having a pleasurable possession.

3. **Materialisation:** refers to aspects concerning the actual physical materialisation of an object; these include:

3.1 **Materials** and their characteristics: meaning the manufacturing technologies, available tools, and machinery necessary for the conception of the artefact.

3.2 **Operation:** How the artefact works, that is, the action of functioning or the fact of being active or in effect.

3.2 **Structure:** the arrangement of and relations between the parts or elements of the artefact; a structure can be dynamic or static, it balances forces and equilibrium.

3.4 **Configuration:** The precise geometric solutions and concrete dimensioning of an artefact.

3.5 **System:** The combination of product, services, processes, required to make an artefact work, to fulfil its function.

4. **Human factors:** these refer to specific requirements that constrain the artefact. These factors are entwined with the category of function. The main difference is that functionality deals with more subjective aspects of the interaction between artefact and user, while human factors are more precise and objective features such as height or age for example.

4.1 **Ergonomics:** Ergonomics studies the physical requirements of the human body; it features anthropometric data that details the average dimensions of the human body, and an attempt to optimise common bodily positions while sitting, driving, typing at a computer, working in factories, and so on (Tilley & Associates, 2002).

4.2 **User requirements:** specific user requests, wishes, or demands.

4.3 **Economic factors:** the cost.

4.4 **Sustainability:** the capacity of the designed artefact to have a low impact on the overall ecological/sociological/economical context⁶⁷. And the extent to which the designing behind the artefact is resource efficient and durable.

⁶⁷ We use the term sustainability in the strict sense we refer; there is a vast literature (see, for instance, [Fry, 1999; Manzini & Jegou, 2003; Papanek, 1972]) on sustainability and design, the extent of which could not be reasonably covered in the context of our thesis.

5. **Communication:** refers to the artefact as part of the built environment and material culture; it concerns the implications of understanding an object as a sign, that is, the meaning(s) it conveys in a communication process. Design generates the artificial material reality, satisfying practical functions and technical performance are only a part of that reality, a design product also deals with connotations (Fiske, 2010).

5.1 **Denotation** is the literal and immediate meanings of an artefact. For instance, when seeing a chair, one perceives its meaning as an object for people to sit on.

5.2 **Connotation:** are the suggested and subjective meanings that emerge from the interaction with a social and cultural context; keeping with the same example, a throne has different connotations (power, tradition, heredity) than a bar stool (drinking, fun, socialising.)

II Extrinsic elements

Program: the briefing, the client's goals, the objectives, and the constraints of the design problem.

The context of use: whether the artefact's use takes place indoor or outdoor, in a private home, an office, a public square, and so on.

Artefact: what type of artefact it is (e.g. a piece of furniture, or a vehicle) or a reference to a specific part of a larger whole (e.g. a tabletop or a car-door).

Precedent: a reference to past or contemporary examples of similar objects.

Representation: the domain⁶⁸ of sketching and model making.

2.4.6 Meta-design discourse

Meta-design discourse (MDD) is an expression of reflection on designing. It occurs when the teacher or student stop a conversation to consider the action of designing itself. It is an interruption from the immersion in the design process, to consider a reflection on the designing that is taking place.

It is a shift in perspective from working on the design to ponder on the designing. This type of discourse 'breaks the fourth wall' (Adams, Forin, Chua, & Radcliffe, 2014) and result in possible teaching moments about designing; it pauses and focuses the attention on the unfolding of the

⁶⁸ By *representation* we mean references to the domain itself, to the medium, not the activity of modelling which we have discussed in detail previously.

process, the mechanics, the thought processes, the decision-making. A pause for consideration of the process of designing, as it unfolds, but it could address past or future design activity as well.

Both participants can use meta-design discourse. The student may spontaneously start reflecting on her design process, and the teacher can elaborate on the student's design process. Also, the teacher can also refer to his demonstrations of designing to explain, to make visible, to make explicit. So for the teacher, MDD has the double role of either referring to his design process or the student's.

Meta-design discourse is a pause to reflect, in other words, it removes the teacher or student from the immersion on the activity of designing. Since meta-design discourse refers to the activity of designing, a consideration of design activity is relevant here.

Design activities

Dorst and Lawson (2009) proposed a summary of typical design activities. These are general descriptions of what a designer does while designing. These actions define wide-ranging cognitive processes. More precise categories would fragment into dozens or perhaps hundreds of tiny bits of design activity. Cognitive categories, on the other hand, describe more generally applicable forms of thinking.

The descriptions the authors propose are broad enough to fit the purpose of our research. Furthermore, by using the proposed design activities for our analysis, we participate in the ongoing design research discussion. It would be meaningless to come up with different names that would describe approximately the same thing. Therefore, we contribute to stable terminology use in design research.

CORE DESIGN ACTIVITIES

The authors proposed five core design activities: formulating, representing, moving, evaluating, and managing. We will examine each one and point out any alterations in terminology.

Reformulating – We have adapted and slightly changed the definition proposed by Dorst (2010). The author stated that “[w]ithin ‘formulating’, the key activities are the identifying of the key issues in a problem arena and the framing of these in a new and original manner.” (p.133)

As we have seen in chapter 1, it is often the case that the initial constraints of a design situation can be altered during the process right up to the final stages of the project. This *reformulation* of the initial premises of the design problem occurs when designers adopt a new frame. they do so in light of a solution or partial solution. The problem and solution

co-evolve. It is a process, a process of formulating initial constraints and reformulating them as the project unfolds and solutions begin to appear.

Therefore, we think the term *reformulating* better encapsulates the ongoing activity of framing the design situation.

Representing – designers use multiple visualisation techniques and sketching occupies a standout position within these. We could also apply the term modelling, but since we have seen how modelling can also be used to describe a language of design, we will keep with the proposed terminology.

Moving – A design move is a step, an act, or an operation that transforms the design situation relative to the state in which it was before the move (Goldschmidt, 2013). A sequence of design moves constitutes a search process that combines partial solutions and problem constraints to form a synthesis. Synthesis is not reached in one go in a eureka moment, but rather as a part of an ongoing process of design moves.

Evaluating – An evaluation serves to keep a design project on track. As a design project unfolds, there are continuous evaluating moments. We expand this idea of constant evaluation of the state of the project to also include evaluation of the design process as well. Designers often find themselves stuck in their process, or lost in unimportant tasks and errands, and therefore pause and reflect on the state of their work. Project development is dependent on the design process, so an evaluation of both is necessary.

Managing – Managing is the activity of planning and controlling the design project; this means consideration of schedules, deadlines, coordination of design team (when applicable), budget, and making sure the project is running on time.

These five core design activities are not sequential, and not hermetic nor definite. For instance, a designer can *represent* a partial solution, which leads to a *reformulation* of the initial constraints, which in turn creates a new frame, if adopted it represents a ‘move’ in the process which has to be *evaluated*. There is constant iteration between these activities. But of course, it is worth keeping them because they describe different activities and help illustrate how the process unfolds. The primary issue is acknowledging they are discrete but interconnected. We expect to find instances where these activities are reflected upon in close connection to each other.

2.4.7 Design language model

DESIGN LANGUAGE		
Meta-design discourse	Design grammar	
Reformulating	INTRINSIC	EXTRINSIC
Representing	Form	Program
Moving	Function	Context of use
Evaluating	Materialisation	Artefact (type & parts)
Managing	Human Factors	Precedent
	Communication	Representation

Table 13: Design Language Model.

2.5 Design Studio model

In this section, we present a summary of the models and definitions that structure the theoretical framework of the thesis. The diagrams and definitions are fully detailed in the context of each chapter where they can be understood in full. The framework's purpose is to serve as an observational lens for the analysis of the empirical studies.

2.5.1 Types of design conversations

The taxonomy of design conversations corresponds to the overall conditions that frame the dialogue between teacher and student in the design studio. It is the first level of analysis and corresponds to a broader perspective.

The types of design conversations vary according to the following axis:

- Informal – formal;
- Formative – evaluative;
- Private – public;

Other factors that have an impact on the design conversations are the project stages; if the meeting occurs in the context of an individual interaction or small groups; if there are any deliverables expected; and finally if the conversations take place anytime or at a specific milestone in the project development.

	Desk tutorial	Desk crit	Review	Group tutorial	Group crit	Group review
Informal Formal	Informal	Semi formal	Semi formal	Informal	Semi formal	Semif formal
When	Anytime	Anytime	Milestones	Anytime	Anytime	Milestones
Formative Evaluative	Formative	Formative /evaluative	Evaluative/ formative	Formative	Formative/ evaluative	Evaluative / formative
Private Public	Private	Private	Semi-private	Semi-public	Semi-public	Semi-public
Individual Group	Individual	Individual	Individual	Small group	Small group	Small group
Deliverables	No	No	Yes	No	No	Yes

Table 14: Taxonomy of design conversations

2.5.2 Format of design conversations

The format of design conversations (see figure 5) is the second level of analysis; here we are referring to the actual dynamics of the teacher-student dialogue. Design conversations are the instances of one-on-one dialogue between a teacher and a student while presenting, reviewing, or working on a design project. The format of a design conversation is a dialogue mediated by visual design representations. Visual design representations are the outcome of the teacher or student's modelling.

VISUAL DESIGN REPRESENTATIONS			
Two-dimensional		Three-dimensional	
Sketches	Drawings	Models	Prototypes

Table 15: Taxonomy of Visual Design Representations (Pei et al., 2011)

2.5.3 Design language

The final level of analysis corresponds to the content of design conversations. We consider design language to be the adequate unit of analysis of teacher and student interactions in the design studio.

Design language is the visual or verbal expression of the design process used by teacher or student during a design conversation. The language of design is a language of practice since a design conversation takes place in the context of working, presenting, or reviewing the student's project. The language of design is twofold; it can refer to elements of design (design grammar) or to the process of designing (meta-design discourse).

The language of design is embedded in the format of design conversations. If the design studio established the overall pedagogical context, and design conversations described the format of teacher–student interaction, then the language of design model enables us to examine the *content* of the dialogue between teacher and student in the design studio.

The language of design expresses aspects of the activity of designing as it unfolds. Since learning how to design is the primary objective of design education it follows that by analysing the language we should uncover (part of) the educational process.

DESIGN GRAMMAR

We adopted the term *design grammar* because, while language is a highly complex system of human communication, grammar presupposes a narrower focus on structure, rules, syntax and the combination of different elements to form a larger whole.

Therefore, we define design grammar as the specific elements of the design domains that constitute the several parts of a whole design. Design grammar can be understood as the elements used to design, that is, the parts and relationships between them, that are synthesised in the form⁶⁹(understood as a unified structure of parts) of an artefact.

Note that, ‘design grammar’ is not synonym with ‘design domains’. Design grammar is a verbal reference to a design element spoken during a review of a design project, that is, the reference is integrated in the context of discussing a design project. Design grammar is a part of design language, not a set of elements external to the context of the discourse.

Design grammar is a type of discourse that is contingent on the conversations that unfold during the act of designing; it is not separate from the context in which it is spoken.

META-DESIGN DISCOURSE

Meta-design discourse (MDD) is an expression of reflection on designing. It occurs when a teacher or student stop a conversation to consider the action of designing itself. It is an interruption from the immersion in the design process, to consider a reflection on the designing that is taking place.

⁶⁹ It is important to distinguish between the idea of shape, which is the outline, contour or external surface of an object, and form. Form is a broader and harder to define concept. Arnheim (2004) adopted the formulation ‘form is the visual shape of content’ (p.96), thus proposing that form is a visual entity connected with the actual materialised shape of an object. According to Arnheim, form is a mental construct, employed when referring to the essential (immaterial) qualities of an object, whereas shape is better used to describe an object’s physical appearance.

2.5.4 Design studio model

The design studio model summarises the essential features of each level of analysis:

DESIGN STUDIO MODEL					
1. Design studio					
Desk tutorial	Desk crit	Desk review	Group tutorial	Group crit	Group review
2. Design conversations					
Teacher — VDR — Student					
3. Design language					
Design grammar			Meta-design discourse		

Table 16: Design Studio Model.

Chapter 3

Methodology

3.1 Introduction

In this part of the thesis, we present a series of four case studies conducted in the real context of design studio settings. The case studies are the empirical side of the theoretical exploration we introduced in chapter 2. We concluded chapter 2 with a description of the defining features that make up the setting of teacher-student interactions in a design studio. The configuration we described established the guidelines that were used to conduct the studio observations and analysis⁷⁰.

3.1.1 Case studies overview

The case studies cover different course years (table below) and four different teacher/student pairs. All the case studies reflect a real design studio environment, that is, the author had no influence whatsoever on the conditions of the classes observed. The objective was to delve into an actual design studio setting and impartially observe teacher-student interactions as they naturally occurred.

CASE STUDIES OVERVIEW				
	Year	Course	Project	Participants
CASE STUDY 1	2 nd year undergraduate	Ambient Design	Subway station	Grace (teacher) Dylan (student)
CASE STUDY 2	1 st year undergraduate	Product Design	Signs, patterns, and 3D structures.	Ella (teacher) Janis (student)
CASE STUDY 3	1 st year master	Product Design	Tram	Albert (teacher) Paul (student)
CASE STUDY 4	1 st year master	Product Design	Tram	Robert (teacher) Patti (student)

Table 17: Case studies overview.

The first two case studies concern undergraduate design students, while the final two focus on graduate design students. Case study 1 presents several interactions between one 2nd year student and his teacher during two design studio sessions; the briefing is very open, and the student is encouraged to explore light and colour as essential elements in the overall atmosphere of a space. In the second case, we follow two design conversations between a teacher and a student during a 1st year studio session. The briefing proposes an abstract exploration of a graphical sign

⁷⁰ The analysis went through successive tiers of analysis. Some of the preliminary results were presented at design conferences (Ferreira, Christiaans, & Almendra, 2011; Ferreira & Christiaans, 2012, 2013).

as a constructive module (in both two and three dimensions). The third and fourth case studies were done in a course which is conducted by two different teachers; the teachers are not present at the same time during the sessions. Both cases present one extended interaction with one student and one teacher as they work on the project of a new city tram.

The bulk of the chapter is composed of the case study reports. Each report closes with a conclusion; as the studies progress we build on the previous conclusions and use this section to compare the findings.

3.1.2 Methodological approach

In this section, we present the methodology used for the empirical studies that support this research. The principal method applied was the case study; there are several ways to conduct case studies and to analyse the data that results from the direct observation of phenomena. As we will see, to produce the best possible results it is crucial to adapt the case study methodology to the object of study.

Our approach was based on the general case study methodology, which we adapted to the specific conditions of our object of study. It was necessary to consider the specificity of the design studio setting when we designed our research methodology. It can be misleading to apply research methodologies directly to design activity without taking into account what is particular about design; the practice of design education has relevant features (specified in chapters 1 and 2) that should be taken into consideration when moving to the field. Therefore, we developed a method of observation and analysis that allowed some flexibility for our research procedures.

To put this observational and analysis framework together implied some trial and error. The methods used in the verbal analysis went through several moments of refinement; this process was time-consuming but necessary. As it was previously described, the design studio setting is currently understudied, an exploratory investigation requires some methodological flexibility to produce useful results, and the rush to obtain results from observation may compromise the study's potential.

In this way, to obtain some flexibility but at the same time having a stable structure from which to depart, we arrived at a research design divided into the following three phases: data collection, creating the database, and database analysis.

CASE STUDY RESEARCH DESIGN	
Phases	Procedures
1. Data collection	Field observations Audio recordings
2. Creating the database	Transcription Translation Development of analysis table
3. Database analysis	Conversation analysis Grounded theory

Table 18: Case study research design.

This tripartite structure allowed us to gain time and have some stability in research. The idea is that the first two phases can be planned and run according to the research schedule; the resulting database can then be analysed and re-analysed repeatedly. Isolating the analysis phase allowed us to have the time to experiment with different approaches to examine the data and study it carefully.

As explained in the first chapter, our general research design was based on some pre-assumptions and research approaches. Given the underdetermined state of the design studio setting, to apply a predetermined framework of analysis seemed premature. As such, during the phase of analysis, we continually compared our observations with what we found in the literature review. The process was dialectical, and it is part of the research design that these two activities (data analysis and developing the theoretical framework) emerge in parallel, one feeding the other.

Next, we will detail the specific methods and procedures applied. Also, we will include a discussion of the case study as a research method used in the study of design activity, including particular difficulties inherent to the studio setting. Then, we elaborate on the set of methods, procedures, and analysis used in our empirical observations. The methodology we described here was consistently used for all the case studies.

3.2 Methods

In this section, we describe the methods applied to conduct and analyse the case studies. The set of methods, approach, and procedures apply to all the case studies (1 through 4), and therefore the methodology is presented as a whole in this section. However, before each case study, we will present the background of the study and highlight any relevant contextual particularities as well as any variation of the methods used.

The empirical work is based on the application of the case-study methodology. Before elaborating on the specific methods employed in this research, we will consider the applicability of the case study methodology in design research.

3.2.1 The applicability of case study methodology in design research

Case study methodology seems to be particularly useful for the goals we aim to achieve with this research. As we have seen in the first chapter, the design studio – and teacher-student interaction in particular – still lack consistent and empirically based description, understanding, and explaining. The purpose of the case studies we conducted was to arrive at a better characterization and understanding of this setting; by doing so, we hope we can also contribute to explain it better.

Case studies provide the opportunity to engage with the real context of any particular phenomena. In his introduction to case study methodology, Tellis (1997b) states that the “[c]ase study can be seen to satisfy the three tenets of the qualitative method: describing, understanding, and explaining.” (p.3)

The applicability of the case study methodology in design research has been addressed by Breslin and Buchanan (2008); the authors argue for the validity and applicability of the case study methodology in design; in the authors’ own words: “[c]ase studies are a useful tool for research and teaching that focus on the transition between theory and practice. The format has been widely used in other disciplines, and it can be used effectively in design.” (p.36)

Breslin and Buchanan’s reflections are centred mostly on the use of case studies as an alternative way to teach students how to design: “[the case studies] cannot tell what decisions should be made, but they can connect the student to social phenomena, real-life experience, and existential situations in a way that helps to sharpen thinking and inform decision-making.” (p.37) However, the authors also observe that despite its potential as a research method, case studies have seen little use in design research, perhaps because of the indeterminacy of the design process: “while most design processes follow a similar pattern, they are subject to many variations in practice, based on personal idiosyncrasies as well as differences of circumstance and product type.” (p.37)

The quotation above highlights an important aspect: designing is not a repeatable activity; that is, while the use of heuristics over time might eventually result in a particular *way of doing*, this form of doing is still idiosyncratic of a specific individual or team. Furthermore, there is the issue of the extent to which a set of particular heuristics can be formalised and transmitted to others. Building on Breslin and Buchanan’s

reflection, we argue that it is precisely because design is a contextual dependent activity (Dorst, 2010), which is to say, designing is unique and seldom repeatable, that the case study is relevant for the study of designing. The point of the case study methodology is precisely to delve into specific phenomena in its real context and proceed to examine it thoroughly.

This principle holds for the study of design education as well. We have established the pre-assumption that design instruction is fundamentally the teaching of design practice. In other words, designing is an integral part of what takes place during design education, as such, the issues related to the uniqueness of designing are expected to be present in the design studio educational setting.

Therefore, from the observation of particular instances in the form of case studies we expect to uncover part of what is universal about the practice of design education. Indeed, teachers have different teaching styles, and students will vary in how they learn to design as well, but underneath these variables, there is a standard structure to the teaching/learning process of design. Note that, unpredictable as it may be, teacher-student interactions take place on a common setting constituted by the same actors (teacher and student) engaging in the same activity (designing) using the same medium (visual design representations) for the same purpose (the teaching and learning of how to design through practice.)

THE DESIGN STUDIO SETTING – CONSTRAINTS, COMPLICATIONS, AND CHALLENGES.

The design studio setting has defining characteristics that hinder observations and data collection.

First of all, the design studio is a private working space, that is, while physical access might not be difficult (in general there are no closed doors in a design studio) the design studio, besides being a physical space, is also a social community (Dannels, 2005), it is, in short, a place where students spend the majority of their time together. Thus, the researcher is inevitably an outsider. To what extent our presence in the studio affected the participants is difficult to determine.

To mitigate this, we sought to collect data subtly, which meant we decided not to use video recording. Furthermore, we never interrupted nor talked with the students and tried to remain, as much as possible, in the background.

Another difficulty concerns the collection of audio and visual data. The data collection was conducted by one researcher; the method was to shadow the teacher as he wandered around the studio space. The researcher had to pay attention and take notes while making sure the

audio was being captured. Thus, visual design representations (such as sketches) were hard to photograph; it is troublesome to keep a distant, in the background, non-interventionist role and still be able to collect data on visual design representations.

In short, one-on-one interactions are particularly hard to observe; the researcher is invading a setting where a considerable amount of privacy is one of its distinguishing features. If at first, our presence in the studio was little more than a quaint novelty, there were moments when it was clear that the teacher and student preferred to be undisturbed and engage privately.

3.2.2 Case study methodology

There is a consensus regarding Robert K. Yin's *Case Study Research: Design and Methods*⁷¹ (2008) as the template for case-study methodology. The author describes the procedures to follow to obtain the highest quality results from using the case study method. Complementarily, we have also consulted the encyclopedia of case study research (Mills, Eurepos, & Wiebe, 2010)[□], as well as Tellis's twofold explanation of Robert Yin's approach (Tellis, 1997a, 1997b)[□].

Yin's work is founded on the principle that "the case study method allows investigators to retain the holistic and meaningful characteristics of real-life events." (2008, p.61) This principle aligns with our objective of establishing this thesis on a foundation of real-life empirical data. In more detail, Yin compares the case study with other research methods (such as experiments or surveys) and concludes that the case study is relevant when: (1) the type of questions being asked are 'how' and 'why' (instead of 'what', where, or 'how many'); (2) when the researcher has no control over the behavioural events and (3) when the events are contemporary (instead of historical).

As a definition, the author proposes that the case study is an empirical inquiry that "investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." (p.111) In other words, a case study is particularly applicable when trying to explore and understand a real-life phenomenon in depth, especially in those cases when it is difficult to separate the phenomenon from its context, as is the case of the design studio.

The object of study of our research – teacher-student interactions in a design studio setting – requires an immersion in the real-life context

⁷¹ At the moment of writing this thesis, the manual was in its fourth edition, which is the one we consulted.

where it occurs. Therefore, Yin's views appear to be particularly applicable. Of course, it would be possible to isolate one teacher and one student and develop a research experiment around their interaction; however, it is our view that to fully understand teacher-student interaction we need to examine it in its natural context.

TYPES OF CASE STUDIES

According to Yin, there are three general case study approaches, which are (1) exploratory, (2) explanatory, and (3) descriptive case studies.

Explanatory cases are aimed at establishing causal links, these cases are suitable when trying to answer 'who' or 'what' type of questions and the complexity of the context means that using a survey or experimental strategy would not be advisable.

Exploratory case studies are implemented to examine situations in which the phenomenon being observed is open-ended and thus has no clear outcomes; as an example, Baxter & Jack (2008) present the case of an observational study of a nurse-patient relationship as a typical case of exploratory case-study. Also, exploratory case studies are often conducted in exploratory stages of research.

Finally, a descriptive case study is conducted to describe a phenomenon and the real-life context in which it occurred. This type of case study requires that a framework of the study and a theoretical description of the phenomenon be developed a priori.

After establishing these differences, Yin warns that "the clarification does not imply that the boundaries between the methods—or the occasions when each is to be used—are always sharp. Even though each method has its distinctive characteristics, there are large overlaps among them." (p.72) This is certainly the case with our research. While we think an explanatory approach would not be entirely adequate, it seems clear that in the case studies we report, the purpose should be both exploratory and descriptive.

PROCEDURES AND COMPONENTS OF A CASE STUDY

Yin also encourages the development of a sequence of multiple case studies examining the same phenomenon, an approach that enables the researcher to explore differences and similarities between cases, thus facilitating comparisons and predictability. In our research, we conducted four case studies (comprising four different teacher-student pairs) which build on each other and allow the establishment of comparisons between results.

Included in Yin's work is a general case study methodology that consists of a proposed sequence of procedures and a description of its components.

Regarding the procedures, Yin (2008) offers a methodology divided into four stages: (1) Design the case study, (2) Conduct the case study, (3) Analyse the case study evidence, and (4) Develop the conclusions, recommendations and implications. As for the components, a case study should include the following components:

1. The study's questions,
2. Its propositions, if any,
3. Its unit(s) of analysis,
4. The logic linking the data to the propositions, and
5. The criteria for interpreting the findings

Next, we will detail how this general framework was applied in the field.

3.2.3 Methods and procedure

The methods used to conduct the case studies are divided into three phases: (1) data collection, (2) database development, and (3) database analysis. The data collection phase was conducted by one researcher (the author of this thesis), while database development and analysis was done together with the research supervisors.

DATA COLLECTION

The first phase concerns the field observation conducted in a design studio setting. The observations are composed of the audio-recording of the individual conversations between teacher and students, note-taking, and visual records of the sketches, drawings, or models that were part of the interactions. During this stage the sessions are recorded from beginning to end, that is, we do not select a teacher-student pair before conducting the observation of a complete studio session.

Some of the observed sessions lasted several hours. Therefore it was impractical to transcribe them in their entirety. Having anticipated this, we made notes during the observations about the interactions that had more potential for analysis (longer and uninterrupted conversations between teacher and student, or a sequence of short interactions between the same student and the teacher.)

The researcher was equipped with an audio-recorder, a notebook, and a digital photographic camera. The observations were meant to be as unobtrusive as possible; we used a small audio-recorder to record the teacher/student conversations, and there were no direct interventions from the researcher.

The observations proceeded as such: the researcher followed the teacher as he moved around the classroom, either addressing or being approached by the students while they worked on their projects. During

the sessions, the audio-recorder was always on, therefore releasing the researcher's hands for note-taking or taking pictures. In order not to lose track of the proceedings we assigned an individual code for each student and used it to mark the time of the interactions and any observations or notes we considered relevant.

DATABASE DEVELOPMENT

The second phase consists of creating a database for analysis. This stage is crucial to convert the collected data into a format that facilitates analysis.

The database was created following a sequence of steps: in the first step, the research team listened to the recordings together and went through the field notes of the researcher that conducted the observations, the team then selected the teacher-student conversation (or sequence of conversations) to be analysed. To choose the teacher-student discussion that would be examined, we considered the following criteria:

1. Sequentiality: a sequence of interactions between the same student and teacher allow us to examine how the project evolves from conversation to conversation, and how (or if) the student builds on what was said before. A series of interactions adds more layers for interpretation, with each conversation adding depth to the teacher-student dialogue.

Alternatively, if there is no sequence of interactions, we can consider:

2. Duration: a long span of a single uninterrupted dialogue has a similar potential to a sequence of shorter interactions. If teacher and student engage in a lengthy conversation, it is expected that the project might evolve, that both parties might build on each other's input, and a rich and complex dialogue can unfold.

Of course, these criteria are not mutually exclusive. A sequence of extended interactions would, naturally, be ideal; but it is not likely that that is a common occurrence (considering the number of students per class and time limitations). One final criterion is more technical and concerns the quality of the recorded data since a sequence of conversations (or a long one) is only useful if we can analyse the data.

After the research team selected the teacher-student interaction that would constitute the design conversation of the case study, it was necessary to create a database that would support the analysis. The database was created in three sequential activities: (1) transcribing (2) translating and (3) analysis table.

First, the research team transcribed the audio-recordings⁷², a task

⁷² To preserve the anonymity of the participants, in the final transcripts we proceeded to

followed by the translation of the transcripts from Portuguese to English⁷³. Next, we inserted the transcripts into a table. The table registers the teacher–student interaction from beginning to end (see table below as an example). The interactions were further divided into sequential verbalisation units,⁷⁴ and included data such as timestamps, pseudonyms, verbalisation word count, notes, and a column for coding.

Case Study 3 Robert & Patti					
Teacher/ Student	Verb.	Transcript	Analysis	Notes	Length (words)
Robert (t)	1	<i>Okay, I have already seen these.</i>			6
Patti (s)	2	<i>These ones I don't think you've seen... so, I kept making sketches...considering possibilities...</i>			13

Table 19: Example of an analysis table (fragment)

The table is divided according to the basic unit of analysis: the verbalisation. A verbalisation is an uninterrupted sequence of speech (Fairclough, 1995). This database is still devoid of interpretation but already includes important data that can be identified, and that reveals some aspects of the dynamics of interaction: for example, it is possible through the database table to understand which of the two participants spoke more time and who said more things (word count). This data is a quantification that requires analysis and interpretation in the general context of the interaction. In other words, the database table organises the information; it does not interpret it.

DATA ANALYSIS

Finally, the third phase corresponds to the analysis of the database. Data analysis is the determining part of the research; all insights result from the work done at this stage. Therefore we will devote particular attention to detailing how the analysis was conducted.

The raw material (audio recordings, photographs, and notes) gathered

de-identify any individuals (in this case teachers and students) by replacing names with pseudonyms. We used the convention of maintaining the first initial and the person's gender; for consistency, we used English names for all the pseudonyms regardless of the individual's nationality.

- 73** The research was mainly conducted by the author of this thesis, however, the analysis of the data was performed a team of three researchers that included a member which is not fluent in Portuguese. Therefore the database had to be translated to be understood by all the elements of the team. This step was necessary since part of the coding procedure required that the transcripts were analysed by three elements of the research team.
- 74** A verbalisation unit consists of the spoken output of each of the participants (teacher and student), it begins when a participant starts speaking and ends when the other participant takes a turn in speaking.

during the observations was stored, and we mostly used the analysis table with the matching transcriptions and notes (nonetheless, during analysis, we often had to refer to the audio to confirm critical contextual elements such as tone of voice, irony, laughter, and so on.)

The methods for data analysis were adapted from several sources to fit the purpose and aims of our research; in other words, we had to design the research methodology to meet our objectives. We will describe them in what follows and summarise the analysis approach in the end.

3.2.4 Methods of analysis

Analysis of verbal protocols is recurrently used to examine design activity (Lloyd, Lawson, & Scott, 1995) and has become one of the methods employed by researchers to try to access and describe designers' design processes. However, as we briefly discussed in chapter 1, it is different to observe and analyse an individual which was prompted to 'think aloud' (usually in a laboratory setting) as a way to disclose short-term memory when performing a specific task, and to observe people talk with each other in a real-context design studio; as we said before, the former situation removes the conversation from its natural occurring setting.

Therefore, in our studies, analysing the data required methods that acknowledge the setting in which they took place. We found that a combination of *conversation analysis* and *grounded theory* was an effective way to address the objectives of our research and the type of data collected.

CONVERSATION ANALYSIS

Conversation analysis (CA)⁷⁵ is the study of naturally occurring dialogue to discover how participants understand and respond to one another during their turns at talk (Hutchby & Wooffitt, 1998). The purpose of CA is to uncover the tacit reasoning procedures (in our case, design thinking) and sociolinguistic competencies (design language) that people use in the development and interpretation of talk.

A fundamental assumption that underlies conversation analysis is the principle that social phenomena are observable, i.e. anyone can see it, write it down and build an observational study around it. Underlying this assumption is the belief that a social phenomenon is better described inductively. In his lectures, Sacks (1995) argued for the development of a naturalistic and mostly observational science of social life, supported by methods that enable the reader to hold as much information as the author,

⁷⁵ Conversation analysis was originally developed in a series of lectures by Harvey Sacks which were later edited in a two volume book (Sacks & Jefferson, 1995).

and is, therefore, able to reproduce the analysis (which does not mean they will reach the same conclusions). This is a principle we uphold with our studies by providing all the data and as thorough a record of how the analysis unfolded as possible.

So, a distinctive feature that inspired the development of the CA approach is that theoretical ideas should be rooted in empirical observations of naturally occurring conversations, as Hutchby and Wooffitt (1998) state “the most distinctive methodological trait of CA, and certainly a policy that underpins all its analytic findings, is that research is based on transcribed tape-recordings of actual interactions” (p.14), this approach aligns with the purpose to base our studies in the real context of design studios. Hutchby & Wooffitt add that “the activities which are recorded are situated as far as possible in the ordinary unfolding of people’s lives, as opposed to being prearranged or set up in laboratories.” (p.14)

In short, CA is an inductive and empirical way to address social phenomena. The approach which CA generally suggests is to view speech as actions which are situated within specific contexts or to put it another way, CA deals with the actual words and the particular order that spontaneously unfolds between people interacting in a specific context. Therefore, a declared concern with real-world data and with the situated nature of talk is a core feature of the conversation analysis method.

The critical element of conversation analysis concerns the arrangement of transcriptions into turn-taking verbalisations (Sacks, Schegloff, & Jefferson, 1974). In fact, the central mechanism of CA is precisely the analysis of turn-taking, which is the idea that the shared understanding, interpretation, and meaning-making that emerges between participants in a conversation can be analysed by considering how a person follows up on what the other has said. Thus, the issue is how a person understood what another has said, but of course, that understanding may align with what the prior speaker intended or it may not; nevertheless, the understanding or lack thereof is revealed in the next turn in the sequence. Thus, the turn-by-turn unfolding of interaction facilitates analysis and determines the identification of sequences of talk within a conversation.

Therefore, a concern with how the ‘next-turn’ clarifies what the ‘prior-turn’ was about, leads to a focus on how sequences of actions are generated instead of concentrating on isolated utterances. This is clear in the table of analysis we presented above. As we can see, each conversation is divided into several verbalisations that represent turns. When discussing studies that use protocol analysis, Lawson (2004)□, recognised that ordering talk into single verbalisations ran the danger of data fragmentation and proposed that design researchers (when using protocol analysis) keep in mind a temporal as well as relational approach.

The temporal approach divides the protocol into time slices and places it in a sequence (as we did with the analysis table) however, when such divisions are too small they may become arbitrary and separate events that are related. So, Lawson argues, it is crucial to analyse the protocol keeping the integrity of the related events, which requires careful interpretation of the data. Accordingly, analysis of transcribed conversations should adopt a temporal/relational approach that places single verbalisations within sequences to maintain the integrity of the conversation. It would be a waste of time and potential to go into the field and then shred the collected data to ever smaller fragments and lose the sense of the whole talk and its context. This is crucial for our work since we decided to go into the field precisely because we wanted to observe the teacher-student interactions as they occurred in a real context.

A way to deal with the temporal – relational issue is to focus on how meaning emerges from the careful consideration of the natural turn-taking dynamics of a conversation since the analysis of the turn-by-turn unfolding of talk should contain the information to interpret what sense the participants are making of the conversation.

Therefore, it is the interpretation of what happens within each turn that guides conversation analysis; the 'next turns' are crucial to interpreting 'prior turns,' another way to put it is: it is the next turn that contains the information (the evidence) that allows the analyst to interpret the prior turn. Careful consideration of turn-taking is then the primary tool used in CA that ensures – to a degree – that the analysis follows the natural unfolding sense-making of the participants, rather than the assumptions of the analyst.

And the sense the participants are making is what matters when studying conversation between people in the context of real everyday events. Notice that, regardless of how we may think a conversation should unfold in a design studio (or what the literature on the matter suggests) it is the people actually engaging in talk that will generate the meaning of a conversation, interpret it, and then react according to that interpretation. In an inductive and empirically based research, it is from the analysis of such particular events that patterns of universal knowledge emerge.

Be that as it may, one of the aims of research is contributing to theory making (Christiaans, 1992); and we aim to add to the understanding of the design studio setting. As such, we found it useful to apply the procedures of Grounded Theory to transition from particular to universal knowledge. In general terms, grounded theory is a method that aims to develop theory from empirical data; in the next section, we will describe its key features and how they are useful for this research.

GROUNDED THEORY

Grounded theory is an empirical method of generating theory from data proposed and developed by Glaser & Strauss (2006). The theory describes a method of qualitative research that investigates a specific phenomenon and generates theory from the empirical findings. It is often contrasted to deductive theories which start from concepts and theoretical frameworks for the explanation of empirical phenomena.

This method proposes that the generation of theory be obtained from the data collected in the empirical studies, and not from other sources (such as textbooks or lectures) or deduced from a priori theories. The main advantage is that we give primacy to what is observed and do not try to find examples that justify and validate a theory established beforehand.

Grounded theory is preferably used when there are no existing theories or only incomplete theories about the object of study, that is when the current set of theories do not describe the setting accurately. Instead of developing another theory by deduction, with the grounded theory method we can generate theory by induction because the theory emerges from the analysis of the phenomenon under study.

This approach emphasizes research on the discovery of insights in the data being analysed rather than on the verification of theories established a priori by logical deduction. The primary objective of grounded theory lies in the previous step of discovering concepts and hypotheses relevant to the study area. In this sense, it is more adaptive to an exploratory and descriptive investigation.

Glaser and Strauss warn, however, of the danger of approaching the object of study without any primary guiding lines: “[o]f course, the researcher does not approach reality as a tabula rasa. He must have a perspective that will help him see relevant data and abstract significant categories from his scrutiny of the data.” (p.4) This warning suggests that the grounded theory method should not be followed strictly and without an adequate understanding of the object of study and methodology to apply. Although it does not serve to test theories by deduction, a researcher who uses a grounded theory approach needs to have some prior understanding of the setting of his studies, even to realise what faults may exist in its description that can be better understood with empirical observation.

Connecting empirical data with theory

As a way of combining the insights gathered from an analysis based on grounded theory with the theoretical realm, the authors suggest that the researcher “chooses examples systematically and then allows them to feed back theoretical control over his formulations” (p.5); the dialectical relationship between theoretical review and empirical data analysis is

essential to ensure that the data obtained is operationalised in a general theory that describes the phenomenon of study.

The process of generating theory from data means that most hypotheses and concepts are systematically related to the data during the investigation. That is, the methodology of grounded theory implies a cyclical inquiry process with sequential tiers of analysis, comparison of the interpretation of the data with the concrete examples observed, and reanalysis of this work. From this process will emerge a theoretical framework that is sharpened with every round of analysis. The data is compared with the emerging framework and vice versa in a dialectical process, in other words, the theory emerges slowly and is continuously checked with the data to see if it adequately explains the observed phenomena (we will detail the methods and procedures further ahead).

This way of analysing real phenomena is consistent with the guidelines established by Yin (2008) in his case study methodology. Yin argued that while the analytic strategy for case studies relies on the theoretical propositions to analyse the results, it is often the case that when the current theoretical understanding is insufficient to explain the actual empirical events, it is better to develop a case description that serves as the framework for examining the case study results. In other words, Yin suggests two possible approaches for analysis: if there is a stable theoretical framework then we should derive propositions from the already established theories to be applied to the analysis; on the other hand, if the object of study is underdetermined, then the analysis should be based on the empirical findings themselves.

Thus, the theory should result in clear enough categories and hypotheses so that critical ones can be verified in the present and future research. One of the advantages of this approach is that since the categories are discovered through exploration of the data, practitioners involved in the area to which the theory applies will usually be able to understand it. That means, in our case, design teachers will be able to recognise the concepts used in the description and analysis of the observations because they do not appear de-contextualised from the current practice.

For the analysis of the case studies we present here, both approaches suggested by Yin were applicable. As we have seen in the previous chapters, teacher-student interactions in a real context lack consistent empirical study; we concluded that the theoretical frameworks that aim to describe the teacher-student interactions in a design studio from a top-down, or deductive, approach were incomplete.

Glaser and Strauss also suggest that one of the criteria for judging the usefulness of a theory can be derived from the way the theory was generated. The authors add that an inductively generated theory of

empirical observation will always be relevant to the people involved in that practice (in the case of this thesis: teachers and students of design) and for researchers of the area because it will generate information based on real phenomena.

Therefore, the theoretical framework we presented in Chapter 2 emerged from the confrontation of the literature review with the field observations. That is when the field work was conducted the theoretical framework was under development. The successive tiers of analysis during the case studies informed the development of our understanding of the theoretical framework, which in turn refined and sharpened the interpretation of the results.

In short, the analysis is based on conversation analysis combined with the application of a grounded theory methodology which is then confronted with the literature review. The data went through successive tiers of analysis that sharpened the theoretical framework, resulting in a theoretical framework strengthened by empirical findings.

Reliability and validity

Glaser and Strauss also address the issue of reliability and validity. The authors state that a grounded theory methodology is by nature a flexible and qualitative method of research, and proceed to argue that the crucial elements of social interaction studies (such as the design studio setting) are often found best with a qualitative method, in particular because “qualitative research is often the most efficient way to obtain the type of information required and to contend with the difficulties of an empirical situation.” (p.18)

Taking into account the qualitative nature of grounded theory, as well as its connection with both an empirical phenomenon and a flexible research design, the authors suggest that researchers avoid the temptation to use validation methods typically employed in quantitative methodologies:

This criticism stems from sociologists' taking as their guide to credibility the canons of rigorous quantitative verification on such issues as sampling, coding, reliability, validity, indicators, frequency distributions, conceptual formulation, hypothesis construction, and presentation of evidence. But in this book we have raised doubts about the applicability of these canons of rigor as proper criteria for judging the credibility of theory based on flexible research. (p.224)

This warning from Glaser and Strauss is reiterated by Uwe Flick in the book *An Introduction to Qualitative Research* (2009) where the author suggests that qualitative research strategies should follow validity standards appropriate to their methods. Flick addresses the issue as follows:

Firstly “the genesis of the data needs to be explicated in a way that makes it possible to check what is a statement of the subject and where the researcher’s interpretation begins.” (p.387) That is, it is a fundamental part of the researcher’s work to ensure an effective report of the case study in a way that allows the reader to distinguish between the analysis (which includes a considerable amount of interpretation) and raw data. A thorough presentation of results allows the methods of analysis to be displayed, which has the advantage of permitting other researchers to work with the data since it is possible to separate the author’s interpretation from the actual data of the study.

Secondly, “the reliability of the whole process will be better, the more detailed the research process is documented as a whole. Thus, the criterion of reliability is reformulated in the direction of checking the dependability of data and procedures, which can be grounded in the specificity of the various qualitative methods.” (id.) Therefore, the adequacy of research design to the phenomenon under study is crucial to guarantee the reliability of the research process, which reinforces the need to make the procedures used in the field and the analysis of protocols clear and explicit.

The approach suggested by Flick is emphasized by Glaser and Strauss when they state that “[w]e have suggested that criteria of judgment be based instead on the detailed elements of the actual strategies used for collecting, coding, analysing, and presenting data when generating theory, and on the way in which people read the theory.” (p.225) For our investigation, in addition to having presented the justification for our general methodology approach in the first chapter of this thesis, we decided to have an independent chapter where we present our methodology (this chapter); but most importantly, the case study reports were carefully put together to include the full background of the study, the particularities of observation and choice of participants, and a clear presentation of our interpretation.

Glaser and Strauss caution that sometimes it can be difficult to identify the point at which the analysis is complete and more rounds of review will only saturate the data. As such, we concluded the process of review when we came to the conviction of the plausibility of using our theoretical framework for the analysis of teacher and student interactions, and our conviction was based on examples from the protocols. In line with what Glaser and Strauss propose, our approach regarding design conversations is not the only one possible, but we are convinced of its suitability; the authors state that “[w]hat [the researcher] has confidence in is not a scattered series of analyses, but a systematic ordering of them into an integrated theory. He has, in fact, discovered, through principally inductive effort, a substantive theory about delimited arrays of data,

which he is ready to publish.” (p.225)

The grounded theory focus on generating theory (for the most part) from data also helps to combat the problem of bias in research (i.e. to look for answers on the data that fit what the researcher already believes) “[s]uch bias as he brings to the field is more likely to be checked upon, while his hypotheses are more likely to arise within the field of observation than to be imported from the outside.” (p.225) This approach is contrary to a research methodology that involves bringing a preconceived theory to the field, which can cloud the vision and the researcher can end up “merely writing footnotes to the imported theory.” (p.227)

Next, we will present the specific grounded theory procedures used in the analysis.

Procedures

Glaser and Strauss propose the following sequence of processes when using grounded theory for analysis of transcripts: open coding – axial coding – narrative building – discriminate sampling. Having this structure of procedures as a basis, we adapted the methodology to serve our research design and objectives. The sequence of procedures was as follows:

1. Open coding

Open coding is the first stage of analysis; the researcher determines different categories or themes that are found in the data and codes them (coding occurs when the researcher identifies a part of the transcripts and assigns a category that describes it.) Open coding implies continual comparative analysis, which means that the researchers continuously compare data to the categories to determine consistency in the coding of the data.

At the same time, the researcher should make notes about how these categories interconnect, that is, how they can be generalised in theory. Thus, researchers make notes to themselves about how the categories are beginning to explain the phenomena observed, and how these categories can be shaped into a theoretical model. In our case, we included here a comparison of the model that was emerging with the already existing theories about the design studio setting that we found in the literature. Hence the result we presented in Chapter 2 is also based on adaptations of previously proposed models by other authors and researchers (such as Schön’s Language of Design).

Open coding is concluded when there are no new categories emerging from the data. The researcher does a final review of the protocols, and if

all the relevant episodes, events, or themes are included in the analysis, then the open coding phase is brought to a close.

2. Axial coding

In this phase, the researcher uses codes and notes to establish how the categories relate to each other. This stage forms the natural continuation of the previous one. During axial coding, the researcher looks for significant connections between the categories and attempts to develop preliminary taxonomies and models. Axial coding often results in visual diagrams, models, or taxonomies that display the meaningful connections between the categories.

In our methodology, this phase often meant a return to point 1 (open coding) for new rounds of increasingly sharpened coding of the data. In this process, early models were abandoned because they were deemed insufficient, or generic (some results have been published, for example, here [Ferreira & Christiaans, 2012]).

During this procedure we gave primacy to the data; this meant that when we reached a preliminary model, the data was checked to see if the model provided insights on the interactions; when we considered the results unsatisfactory, the model was abandoned or altered. The aim was to describe what we observed and not fit the observations into a theoretical model.

3. Building a narrative

In this stage, the researchers write a story about how the theory explains the observed phenomenon. This procedure is particularly useful when developing the case study reports (Yin, 2008).

The building of a narrative to communicate the case studies were particularly useful for our object of study. The best way to convey a complete picture is to describe the design conversation from start to finish so that the details and dynamics of the interaction are not lost in the analysis. In this way, we obtain a focused analysis of specific episodes within an overall context, without losing the sense of the whole.

Putting the information together in the form of a narrative helps to describe the phenomena with more detail and significance. Furthermore, any shortcomings of the research are also laid bare, since the analysis and interpretation are openly displayed. This allows that other researchers may engage with the case studies, question the methodologies presented, and contribute with their proposals.

4. Discriminant sampling

Grounded theory presupposes a repetition of the study with a whole new group of participants to see if the results are similar, and to test and verify if the theory is accurate. This phase was included in the overall research design of our investigation since we established from the start the need to carry out a sequence of case studies in different contexts.

These are the four primary procedures needed to engage with grounded theory. We have adapted these and also included a final stage named *reporting the results*.

5. Reporting the results

This stage brings together some of the leading issues related to grounded theory (such as reliability, reporting, and data analysis) therefore we will take longer to detail it.

In the research studies we present here, reporting the results deals with the issue of presenting the actual events of the case studies. In other words, it is not a simple matter of displaying quantitative results on a table for instance, but rather how to accurately describe a real situation. Glaser and Strauss alert for the problem of describing an actual situation and publishing it: “how to describe the data of the social world studied so vividly that the reader, like the researchers, can almost literally see and hear its people – but always in relation to the theory.” (p.228)

The standard approach is to present data as evidence for conclusions, thus indicating how the researcher generated the theory from the data. However, qualitative data does not lend itself to a quick summary. Thus, the researcher often presents only representative examples occasionally accompanied by tables with quantitative data.

Moreover, if the theory encompasses several ideas, illustrating each one can become unmanageable. Thus, the researcher will often present only enough material to facilitate understanding. To do this, the researcher can use several standard devices for communicating a case study, such as direct quoting of the participants, illustrative segments taken from the field notes, summarise short episodes, and also use background descriptions of contextual elements such as space or other items present during the interaction.

More often than not, the most effective way to convey all this information is to deploy a narrative structure divided by chapter headings if the description becomes too extended: “[i]n most existing case studies, explanation building has occurred in narrative form. Because such narratives cannot be precise, the better case studies are the ones in which the explanations have reflected some theoretically significant

propositions.” (Yin, 2008, p.357)

These descriptions come together in the case study report.

CASE STUDY REPORT

The case study report is divided into three fundamental parts:

(1) Description of events. The first part of the report is the presentation of the analysis and interpretation of the interaction in the form of a narrative describing how the events unfolded. Here, we reconstruct the events of the case study from the field notes, protocols, and photographs (when available).

The description of events includes the transcripts of the teacher-student interactions almost in full, interspaced with the analysis of what is happening during the conversation. When the interaction is extended, the description is segmented into cohesive episodes within the general interaction. It should be acknowledged that we follow the template that Schön (1983) used to present the results of his studies.

The description of events is complemented by the display of another type of data in tables. There are two kinds of table:

a) Verbal analysis: straightforward analysis of the number of words spoken by each participant, and percentage of words per verbalisation.

b) Coding tables: here we present the results of the coding of the protocols; the categories used here derive from the language of design model. It is important to note that these tables are complementary to the description of events and lose its significance if used in isolation.

(2) Discussion. This part of the report addresses the findings and links them to previous studies and research; it concerns the establishing of connections between the results of the case studies and past studies done in the same area.

Furthermore, this phase also serves to make the cross-case analysis, that is, to relate the results of the several case studies of this thesis, with each discussion adding to the previous one. Much of the final discussion of this thesis emerges from this cross-case analysis.

(3) Conclusions. This stage succinctly summarises the findings of the case study.

3.2.5 Limitations of the studies

We chose to conduct a series of cross-section studies of different design studios with various teachers and students. This methodology has limitations we should acknowledge here. Being cross-section case

studies (that is, a study that isolates and focusses on one particular moment in time) we cannot make a longitudinal analysis that could add to the conclusions that we presented here. This was mostly due to time limitations, but also to try to have a broader scope of cases to analyse. Nevertheless, following the same student and teacher throughout several semesters of a design course, would have permitted different kinds of analysis and conclusions we cannot take from a single isolated case study. It would have been interesting to follow a student in subsequent projects to observe if she had integrated this experience into her way of designing.

The sample size is another limitation; the insights revealed by these case studies would be strengthened if replicated with a larger sample. We tried to mitigate this issue by including studies conducted by other researchers in the discussion section, thus integrating the case studies in the ongoing debate on this topic.

Finally, a case study depends to a great extent on the personal observation, interpretation, and analysis of the researcher conducting the work on the field (Yin, 2008). This is an unavoidable part of doing a case study that we tried to attenuate by providing full transcripts in the annexes, but mostly by presenting a detailed case study report that both describes the observations as well as the interpretation and analysis conducted.

Chapter 4

Undergraduates

4.1 Case study 1 — Grace & Dylan

"It seems to me that you are too focussed on representing reality."

4.1.1 Study background

INTRODUCTION

The first case study takes place in the studio class of a *spatial design*⁷⁶ course. The course prepares students to design spaces (both interior and exterior); the emphasis of the course is to combine architectural elements such as space organisation and layout, with furniture design, colour and even sound and graphic design elements to create particular atmospheres. Students that graduate this course can become, for instance, experts in retail design or scenography.

The class we observed was a relatively small group of twenty-five students⁷⁷ enrolled in the first semester of their second year. The briefing was not set in a real-life context, that is, it concerned the design of a space that does not exist. Therefore, the purpose is more on the free exploration of design elements than the practical application to an existing context.

For the sessions we observed it was not required of the students to present any deliverables until the following week. Therefore, the sessions were regular design studio classes, that is, there were no examinations, juries, or presentations, just the usual everyday activity of the class.

The sessions were characterised by short span interactions, and the teacher seldom sat down to work or talk with any student for a prolonged period. Most students had only a couple of brief conversations with the teacher and otherwise kept working on their own (there was, however, constant dialogue between the students themselves).

BRIEFING

The brief challenged the students to create a space through the exploration of several elements (mainly colour, light, communication graphics, and objects). The purpose of the space was left open for the

⁷⁶ Spatial Design is the author's translation of the original Portuguese term "Design de Ambientes".

⁷⁷ While twenty-five students were enrolled in the course; we counted only seventeen students present during both sessions.

students to decide for themselves. However, it had to include the function of a ‘stop’ of any kind (e.g. a bus stop, or a railway intersection).

Another necessary condition was the use of a cardboard parallelepiped solid with fixed dimensions (210x280x210 mm) as the primary tool for their work. The cube’s⁷⁸ twofold purpose was to be a scale-model of the physical reality the students’ were exploring, as well as the final maquette for their presentation.

The brief stated that the final presentation should consist of photographs of the model presented in a poster. During the sessions the students were working on an early stage of their projects (second week.)

STUDIO CONTEXT

The complete observation lasted approximately nine hours; the class-session is scheduled from 09h00 to 18h00 with a lunch break of one hour (comprising a total of two sessions of four and half hours).

The class took place in an open space studio with the students’ desks arranged in two parallel lines running lengthwise. The teacher (Grace) had a pre-assigned desk at the far end of the studio, while the students settled on random empty desks as they arrived. There were lockers to one side of the studio and top to bottom windows (which allowed plenty daylight to enter the room) to the other.

During the sessions, the students settled on their desks and worked on their models, and the teacher (in this study referred to by the pseudonym ‘Grace’) regularly wandered around the studio approaching the students while they worked.

PARTICIPANTS

The case study will focus on the interactions of one student (pseudonym ‘Dylan’) and the studio teacher (Grace). We will elaborate on the rationale for the choice of participants in the Methods and Procedure section below. Dylan’s project concerned the design of a subway station. Grace is both a design teacher and a professional designer.

SUMMARY

Below is a table with a summary of the case study’s context:

78 The solid was not technically a cube; but the students and the teacher often referred to it as a “cube”, probably to make communication easier.

CASE STUDY 1 – CONTEXT	
Context	Design studio class
Course	Spatial Design
Course year	2 nd year / 1 st semester
Project	Subway station
Participants	One student (Dylan) One teacher (Grace)
Number of students present in the studio	Seventeen
Course duration	Five weeks

Table 20: Case study 1 – context

4.1.2 Study questions, guidelines, and aims

This an exploratory study framed by the research aim of describing how the process of teaching and learning how to design unfolds in the design studio. The following questions serve as guidelines for the analysis:

1. What is the result of design conversations?
 - Do design conversations reveal new knowledge about design and designing? If so, to what extent do students reveal they have apprehended it?
 - Do design conversations influence the design project?
 - Do design conversations influence the student’s design process?
2. What is the role of design language in design conversations?
 - Does the design language model reveal the design process of teachers and students and render it more explicit?
 - What are the differences and similarities between teacher and student use of design language?
3. How do the defining features of the design studio influence the dialogue between teacher and student?

4.1.3 Methods and procedure

METHODS

We followed the overall methodology presented at the beginning of this chapter. The stages of research proceeded sequentially as planned: (1) observation and data-collection, (2) creating the study database, and (3) data analysis.

OBSERVATION PROCEDURE

We observed two sessions on the same day, one in the morning and one in the afternoon, with both lasting approximately four and a half hours. With only a general idea of how the teacher conducted the class, we had to deal with unanticipated problems on the spot. These were mainly due to the structureless nature of the session – that is, the teacher often moved around, making short interactions with the students (sometimes lasting only a few seconds) which made it difficult for the researcher to keep track of all the interactions that occurred.

The observation procedure was to follow the teacher as she roamed the studio interacting with students. The researcher had the audio-recorder turned on uninterruptedly and placed on his shirt pocket, thus freeing his hands for note-taking. Finally, the researcher carried a camera hanging over his shoulder.

The primary objective was to collect as much data as possible without disturbing the events. As the teacher moved around and talked with students, the researcher made an effort to stay behind her to pass unnoticed. Since the audio-recorder was always on, the researcher used his notes to keep track of the time when the interactions happened, who addressed whom, if there was any drawing and sketching by the participants and any other occurrence that stood out.

CASE-STUDY 1 OBSERVATION PROCEDURE	
Observer	One researcher
Context	Design studio class
People present	Seventeen students One Teacher One researcher
Duration	Two sessions (total of nine hours)
Equipment	USB audio-recorder Digital camera Notebook and pen

Table 21: Case study 1 – observation procedure

DIFFICULTIES

The main difficulty was observing the class without disturbing it. Design conversations between teacher and students are a private occurrence, to observe the class and collect quality data necessarily means the researcher has to disturb it to a greater or lesser extent.

After completing the data-collection phase, we began the development of the case study database. At this point, the arduous part was transcribing

the conversations. The notes were indispensable to complete this task since we had noted the time of each interaction, it was therefore not necessary to listen to the entire recording of the whole session.

Nevertheless, the studio was considerably noisy with constant talking between the students. This is quite natural in a design studio, and it was not unexpected, but meant that transcribing software was almost useless and therefore we had to transcribe everything by hand. Furthermore, due to the constant ambient noise, some of the interactions became partly either inaudible or unintelligible.

Finally, we must report on a misfortune that happened when creating the database. There was a technical problem which corrupted the SD card when copying the photographs from the SD card to the computer. While this was unfortunate, the researcher had not been able to take many photographs of the occurrences. In fact, the researcher often felt that he had to choose between taking notes and taking photographs, and since the notes were crucial to establishing the context of what was being recorded, he, therefore, did not register many photographs.

Nevertheless, this accident reinforces the necessity of having back-up systems when collecting data or creating the database.

RATIONALE FOR THE CASE STUDY SELECTION – GRACE AND DYLAN

The sessions were characterised by dozens of short conversations between teacher and students. Some lasted less than one minute. Listening back to these short spans of dialogue there was little to work with. Furthermore, since there was considerable background noise many of the recordings were partly or entirely inaudible.

During the sessions we had noticed one of the students (Dylan) had more interactions with the teacher than his colleagues, we also followed the development of his work during the two sessions, as well as the progress of his conversations with the teacher. Thus, already during the data collection, it seemed that Dylan would be the best candidate for the case study analysis.

The reasons to select the sequence of conversations between Grace and Dylan can form a useful basis for future case studies. Grace and Dylan's design conversation is made up of a series of short interactions spread throughout the two studio sessions observed, thus, it is consistent with the two criteria we establish to select the case studies: sequentiality (a sequence of interactions between the same student and teacher) and duration (a long span of a single uninterrupted dialogue). In this case, we have a sequence of conversations that can be understood as one long design conversation split into several moments.

4.1.4 Results

FINDINGS – CASE STUDY REPORT

The case study follows the interactions between Grace (teacher) and Dylan (student). There were ten interactions spread across the two sessions between the two participants.

We begin with a summary of the verbal output of the interactions (table below); this quantitative data serves as a first picture or a point of reference of how the conversations unfolded. The data in itself does not tell us much. It serves the purpose of showing, with relative assurance⁷⁹ who spoke more and for how long. But we must emphasise that we are not drawing definite conclusions from this data alone.

After the verbal output summary, we will present a report with the sequence of interactions as they occurred in chronological order. We will present a narrative with beginning, middle, and end; the report combines description with an interpretation of the events.

The report is followed by tables that display the coding results and summarise the design language used by both participants during the design conversation. Finally, in the discussion section, we elaborate on the results by making a comparison with the theoretical framework as well as with other studies.

Verbal output

TOTAL VERBAL OUTPUT				
Teacher/student	Verbalisations	Words	Mean words/verb.	Word percentage
Grace (t)	54	782	14,4	52%
Dylan (s)	54	723	13,3	48%

Table 22: Grace and Dylan's total verbal output

From the table above we gather that both participants talked a similar amount of times (54 – 54). Also, the number of words spoken was quite close, with Grace (the teacher) registering a slightly higher count of the words spoken during the interaction.

⁷⁹ The word count was done using the translations and, therefore, is approximation.

Description of events

SESSION 1

Design conversation 1.1⁸⁰

The interaction begins after Dylan had settled on his desk. The teacher approaches him and presents a book about modes of transportation (Dylan is working on a project for a subway station). The pair appears to continue a conversation where it had left from a previous day, which suggests their interaction is ongoing between studio sessions and the teacher is following the student's project closely:

GRACE

Had you seen this book before?

DYLAN

No, I didn't even know about it...

GRACE

It's very important that you have this information.

DYLAN

I had no idea...

Both participants are standing next to Dylan's desk; his model stands on top of the table, as well an assortment of materials and tools (x-acto knife, pencils, paper, cardboard, and so on). For now, they focus on the book that the teacher is holding; she flips a few pages looking for information and finally finds it:

GRACE

This is the rails...maybe you should use the dimension of these...just the basic dimension, so that you have a volume.

Neither teacher nor student are, at this moment, working directly with the model; however, in the transcript above, Grace links the information she is providing – which concerns facts about rail width – with Dylan's model. She suggests he should use the basic dimension of rail width, which he can get from the book, to have a basic volume to work with in his model. In this instance, the teacher introduces elements of design grammar into the conversation. Also, she presents the different elements in connection with each other; the teacher addresses a part of the student's design (the rails) linking it to the overall proportion and dimensions of the whole station.

⁸⁰ All quotes in this section can be found in full in the annexes.

Dylan seems to make the connection (between the information about rail width and his actual model) as well when he said:

DYLAN

Yes perhaps that's what... yes, that's it... because I couldn't even find this. I couldn't find this information... I wasn't sure I wanted to work that merely as a cube and this way maybe I can move one of the facets (...)

The “that” in the transcript means the model. Also, notice that Dylan's discourse is somewhat elliptical at first, perhaps suggesting he is reflecting on what Grace said as he speaks. The dialogue continues with both participants wondering if there is any information from the projects of the previous years that he can use, until Dylan shares a couple of insights he had collected from a search on the internet:

DYLAN

Because you know... what I found on the internet, the ratio between a regular train and a subway is very similar concerning the height... the only difference is really the length –

GRACE

Mm-hmm.

DYLAN

And it also varies from subway to subway... they develop the subway lines in such a way... there are several systems... for example, in high demand lines in certain cities... they make it circular, and normally the carriages are smaller.

GRACE

Ah, okay, there's an optimisation –

DYLAN

Exactly.

GRACE

– according to the shape of the line.

DYLAN

The ratio of the subway varies a lot according to the relation of the line.

Notice Dylan's verbalisation “and it also...”, where the student is presenting some conclusions concerning a preliminary research he conducted online. He is talking about a part of the project – the subway lines – by drawing

a connection between the size of subway carriages and higher passenger frequency. The student suggests that line shape, size of carriage, and passenger frequency form a system. The subject matter is quite complex, and it is worth noting the student did not make this reflection on the spot but rather had thought about it before the meeting began. Nevertheless, the student in this instance shows a broad perspective and an ability to make connections across elements relevant to his design.

While Grace follows the student's thinking and they seem to be forming a mutual understanding, the teacher abruptly interrupts the direction in which the discussion was heading:

GRACE

Maybe it's a bit irrelevant if you find the answer to that question or not.

Why did the teacher deliberately interrupt the direction of the ongoing conversation? Let us consider the teacher's statement more closely: is it important, at this moment, to find precise answers to the issues Dylan is raising? If not, what should the student be focusing on?

We observed how the student was showing an ability to make connections across design domains; however, what he does not show, at this moment, is an ability to integrate the information into the project, or more precisely, the research had not led the student to do any work on his project. Dylan's research was moving him away from the concrete experience of engaging with a direct study of the space, his discussion was centred on broad issues (cities, systems...) and not related to any work or problems raised by his specific project.

Also, Grace's abrupt interruption shifts the conversation from the dimension of design grammar to a meta-design discourse level (should Dylan be doing this research at this stage of the project? Or at all?). The teacher's statement represents a pause in the design process to analyse the overall state of the project.

While Dylan seems to be wholly immersed in the task at hand, effectively caught up in the details of dimensions and systems, the teacher can take a step back and question the direction in which he is heading. Incidentally, Dylan does not seem to acknowledge this⁸¹

⁸¹ The teacher's statement had no immediate effect that was verbalised or expressed in any other way by Dylan. We have no way of knowing whether the student even listened to the comment of the teacher or not. What we observed, and what we can say with assurance, is that there was no verbal acknowledgement by the student, and also he did not pause to consider the teacher's statement, but instead carried on with the same discussion as before.

DYLAN

Yes that's it, that's it... so I think the question of the length, so... it would be more the dimension of the whole train...and not the carriage...

His immediate reply was apparent agreement (“that’s it”) only to return to the same discussion as before. It is worth noting that Grace does not insist. Instead, she leaves it up for the student to experiment for himself:

GRACE

Then, you should try it... and keep working on... and keep working already on your cube and the space...

The transcript above was the last of the first interaction. Notice that the interaction ends with the teacher advising Dylan to keep working on his model, which is interesting since the conversation began with the model standing on the desk not being prominent at all. This seems to be a concern for the teacher; with her final statement, Grace re-centres the scale model as the fundamental element the student should concentrate on at this point.

Design conversation 1.2

This part of the conversation begins with Dylan approaching Grace’s desk holding his model. He pointed to a detail concerning the space and they began talking:

DYLAN

Teacher, it’s going to be more or less like this.

GRACE

Mm-hmm

DYLAN

With a... with a...

GRACE

With vertical facets?

DYLAN

Yes, yes!

Dylan highlights a particular aspect concerning the space, but struggles to explain it verbally (“with a... with a...”). Grace can grasp what Dylan is trying to say and expresses it herself (“with vertical facets”).

In this short exchange, we see that Dylan has followed Grace’s advice from

the previous encounter since he is now focused on his model. This is also an interesting example of the three-dimensional model (the visual design representation of this case study) as a mediating artefact; notice that, what the student could not express verbally the teacher was capable of discerning in the model itself.

Design conversations 1.3, 1.4, and 1.5

Segments 1.3 through 1.5 are all concise. As Grace wandered the studio, from desk to desk, she often stopped and offered small bits of advice to students. Naturally, the same thing happened with Dylan. We would not acknowledge these moments if they were not a part of an ongoing conversation. The occurrence was always similar; Grace notices something in the student's work and quickly highlights it with a straightforward comment:

GRACE

Work from a top-view perspective.

DYLAN

Okay.

And also:

GRACE

That's good, because that's where your intervention space is.

DYLAN

Yes... that's it!

And finally:

GRACE

Don't forget to place the cardboard on the side...

DYLAN

Yes... yes...

GRACE

Because it's completely different to see the carriage above the horizontal plane.

DYLAN

Exactly.

All these transcripts are focused on specific attributes of the student's

model. While Grace's comments appear to be relatively straightforward, they nevertheless suggest a pattern in her advice; namely, that all of her recommendations insist that Dylan should use the scale model to see: for instance both "work from a top-view perspective," and "(...) it's completely different to see the carriage above the horizontal plane" are clear exhortations for the student to look at the model from different perspectives and explore its spatial features.

The model, in this case, is a *sketch-model*; that is, it is not a presentation maquette that has the role of communicating a project's overall concept to a client or the general public. Preferably it is used like a sketch, whose inherent ambiguous nature calls for reflection and reinterpretation. It is a tool for thinking and for the exploration of ideas and partial solutions.

Grace's short bits of advice are swift and unobtrusive, perhaps because she finds Dylan immersed in his work and she may be reluctant to interrupt him, her advice is a nudge that keeps the student on the right track.

At this point, the first session was over. All interactions from the first session were short (and the final three particularly so) and tentative. In session two we will observe more extended conversations and witness Dylan's project evolving considerably; what is more, the dialogue increases in complexity with more references to design grammar and repeated instances of meta-design discourse (almost exclusively from the teacher.)

SESSION 2

Design conversation 1.6

In this interaction, Grace approaches Dylan's desk again – as he is working on his model – and sits next to him. The teacher does not interrupt him; she seems curious about the student's project. Dylan has made considerable progress, and the model is now quite different from the beginning of session 1. He has created a pit for the railway, as well as a platform for the passengers.

Grace makes a gesture as if asking for permission to hold the model, Dylan hands it to her, and immediately the teacher starts talking and pointing with a pencil:

GRACE

So, here you can get more depth –

DYLAN

Right.

GRACE

– a certain height which allows you to have more space

to experiment with things... do you understand what I
am telling you?

This is the first time that Grace intervened directly on the student's model. She proposed a solution "you can get more depth" and then asked if the student understood her demonstration.

This is an example of Grace intertwining both dimensions of the language of design. Notice that she refers to depth, height, and space, that is, aspects that apply to the station's overall configuration. However, when Grace suggests Dylan should "experiment more things" she is saying that this arrangement allows him the space to experiment with his design. She is connecting specific (spatial) solutions to the whole (the overall design) and, more importantly, she is anticipating how the process might unfold from this partial solution or *design move*; thus, she is reflecting on the act of designing, as if she is saying: *if you do this now you will be able to experiment more things*.

Grace seems to be aware of the complexity of her discourse since she tries to make sure that Dylan understood what she was saying: "do you understand what I am telling you?". The interaction continued as follows:

DYLAN
Ah! So it doesn't end here?

GRACE
This point...

DYLAN
Mm-hmm

GRACE
...this edge...

DYLAN
Mm-hmm

GRACE
...connects with the height of this plane...

DYLAN
Mm-hmm

GRACE
Everything goes up –

DYLAN
Ah, okay...

GRACE

- and you support this here. Which means you get this extra space here -

DYLAN

Exactly!

GRACE

- in order for this to go to the ground -

DYLAN

Ah okay, now I get it...

GRACE

- you build there... as if it was the pit -

DYLAN

Exactly.

GRACE

- of the rails right?

DYLAN

Exactly. Okay. Okay.

Notice how the teacher's discourse, which until this point had been clear and articulate, now becomes cryptic, monosyllabic, and intertwined with the student's speech. Grace's discourse is at this moment entangled with her manipulation of the model. The meaning of what the teacher is saying depends on her demonstration. Also, there are no instances of meta-design discourse, the conversation is entirely focused on the model, and it mostly concerns design grammar.

The teacher demonstrates with a lot of pointing and holding the model directly, also, notice the use of words such as "there", "here", and "this", that only make sense while pointing and holding the model as a reference.

This is an instance of the teacher designing, she leads the conversation (that becomes a description of what she is doing) and takes control of the dialogue; during the demonstration Dylan punctuates Grace's discourse with several signs of understanding such as "mm-hmm," "exactly," "right," but otherwise, at this point, does not build on what the teacher is saying during the conversation/demonstration.

The example above was an exception. Grace mostly abstained from making any direct interventions on the student's model; instead, most of the time, she suggested ideas and alternatives verbally. The interaction ends shortly after this with the student making a few suggestions of what he might do next.

Design conversation 1.7

During this studio session most students alternated between working on their models and wandering the studio, talking among themselves, and checking their colleagues' progress, the students were less concentrated on their work as the session moved towards the end. In contrast, Dylan continuously sat at his desk immersed in his project.

For this interaction, he gets up from his seat and approaches Grace's desk with his model in hand:

DYLAN

This is how I'm gonna position the...

GRACE

You cross it here...

DYLAN

Yes. And then I'm going to fill it all the way down –

GRACE

But then you won't explore this space here...

DYLAN

But I thought I would do... sort of apply even if it's later... another box in front of it just so that this doesn't get any lower... since I have all this space.

GRACE

Yes, yes... You can even explore... yes, it's more interesting for your exploration because you end up having the same height...

DYLAN

Exactly that's it. And then this whole section becomes more interesting..

GRACE

Mm-hmm.

Similarly to the previous interaction, both Grace and Dylan's discourse is here somewhat cryptic. Both of them appear to have developed a mutual understanding about the project that renders their exchanges shorter and elliptical. They need fewer words to express themselves, as they use the model as a common focus point.

Also, the teacher further reinforces the importance of using the model to explore possibilities "(...) you can even explore... yes, it's more interesting for your exploration(...)" without explicitly stating what the exploration should be; she opens the possibility for the student to experiment for

himself and draw his conclusions.

Design conversation 1.8

This was the most prolonged interaction of this case study. Similarly to design conversation 1.6, Grace approached Dylan's desk and sat next to him as he worked; following on the topic of using the model to explore possible situations and ideas she explains:

GRACE

Imagine that the light... that you go beyond the reality that is represented totally here right?

In the transcript above Grace elaborates on what she has been recurrently saying; the model should be used to explore – and test – possibilities. It is not just a representation of reality (as if it was maquette). She is making the student stop and consider the model differently, suggesting he can use it to see more possibilities worth exploring. The student should go “beyond the reality that is represented totally here right?” After a short exchange, she then elaborates:

GRACE

But what I am suggesting is: what you have here is the model of a real situation right? So, you take advantage of your model and... let's imagine that your project was to manipulate lighting in order to completely change the subway station. You take advantage of your model to show it. You manipulate the light and colour to change the whole atmosphere of the space.

DYLAN

I hadn't thought of that... I was thinking of representing the subway when it had halted.

With his answer, Dylan's seems to acknowledge, for the first time, what Grace has been trying to explain: “I hadn't thought of that... I was thinking of representing the subway when it had halted.”

Grace's explanation made Dylan stop and reflect on his process “I hadn't thought of that...”; the teacher demonstrates how the student should pause and consider how his model can be used differently, in a more explorative manner, as a tool for inquiry and testing of solutions or ideas. She manages this by way of giving a specific example “You take advantage of your model to show it. You manipulate the light and colour to change the whole atmosphere of the space”.

Thus, her design explanations are illustrated by using a concrete

example. Also, the teacher focuses on different elements without losing a sense of the whole, of how every design element suggests different possibilities and relates to each other. She refers to how the elements of light and colour can be manipulated and combined to change the whole atmosphere of the space. And she addresses the scale model as a means to experiment with and explore a real situation.

And yet, while Grace is addressing specific elements and aspects of the design (that we can consider design grammar elements) her concern is also with how these aspects might influence the whole project, that is, she is reflecting on the action of designing. In her speech, design grammar and meta-design discourse are linked.

Grace emphasis is on making the student experiment more; nowhere is this more clear than when she says “let’s imagine that(...)” which is a direct request for the student to use his imagination, to experiment with a different perspective, to reframe his understanding of the project, and to take advantage of this stage of the project to explore ideas and test solutions.

Dylan seems surprised with the possibilities the teacher proposed. He follows up with a question:

DYLAN

So, in order to represent those lighting transformations it would be better to represent the hangar, or not?

GRACE

The whole platform? Maybe... you have to think about what you want to do... but imagine that you also had to intervene in the tunnel... for example, have you noticed the new pt-blue station⁸² in Lisbon. Have you noticed, they seized the station using only light and colour. Every time the subway enters the station it turns blue... so, imagine that you were going to intervene in the tunnel using only light and colour... perhaps the lights turns on in specific moments...

Interestingly, Grace does not give a direct answer, instead, she again urges Dylan to explore more possibilities for himself “(...) imagine that you also had to intervene in the tunnel (...)” and she explicitly tells him he has to think about what he wants to do. With each “imagine that” the teacher stretches the student’s perspective, effectively broadening the scope of

⁸² The PT-blue station is a reference to a sponsoring deal the Lisbon subway done with an internet provider company. The deal meant that the company would name one of its subway stations; as a part of the deal the company was authorised to intervene in the station with blue LED-lighting that conveyed the brand’s presence to the passengers.

possibilities he can explore.

Also, she follows up with a precedent (the “PT blue-station”), which is a real life example that seems to capture and illustrate the ideas she is trying to explain. Grace then suggests Dylan could explore light and colour as decisive elements in the space’s overall atmosphere.

DYLAN

Yes, yes, yes...

GRACE

It seems to me that you are too focussed in representing reality, which is also important because you end up learning to control a series of tools... but add to that an explorative side...

We observe Grace trying to release Dylan from the goal of having to use the model to represent reality (i.e. a maquette of a subway station) instead of a means to explore possibilities and test his ideas.

Dylan hesitantly agrees “yes... yes... yes...” and the teacher goes on to explain how the way his process unfolds will have an implication on what he might learn. Thus, her interjection “(...) which is also important because you end up learning to control a series of tools (...)” seems to be a reassurance that what he has been doing is also important; furthermore, this phrase is also a curious moment of Grace self-reflecting on her teaching, as if she was reflecting on the spot on the possible outcomes of different approaches “(...) you end up learning (...)”.

But fundamentally, we observe again the teacher pausing and thinking about what to do, with what objectives, reflecting about where the project is heading. For the teacher the project at this stage has unstable boundaries, she is continually questioning the student’s current focus, wondering if there might be other solutions, suggesting different perspectives (“imagine that”).

It is interesting to observe how Dylan reacts to the teacher’s input. We have seen how he acknowledged what Grace was trying to say, while expressing a degree of surprise “I hadn’t thought of that...” what follows is the student trying to make sense of the new possibilities:

DYLAN

okay... if I had this cube as a basis... then it could be just a matter of filling the tunnel inside with another colour... that is... the light-beam itself would reinforce the colour of the tunnel.

GRACE

Okay... I don't know...

DYLAN

Let's imagine, the tunnel itself would reflect the light...

GRACE

It's possible.

DYLAN

Those situations when the subway lightens the whole tunnel all around... as if the tunnel would reflect the light... could be interesting... I was thinking, can I represent movement?

GRACE

That's exactly what I was going to tell you next... here you almost need some movement, to add a bit more –

Dylan is enthusiastic about using light as a way of manipulating the space's atmosphere; he suggests a couple of possible uses of this idea, to which Grace offers only tentative answers "(...) I don't know (...)", "It's possible". At this point they also exhibit, again, a certain level of mutual understanding "That's exactly what I was going to tell you next(...)".

Dylan builds on this and proceeds by proposing the idea of presenting the project as an animation.

DYLAN

But then... for example... if I had no movement... lets imagine that... like in the movies... if a camera is fixed on the train... the camera is stopped, the subway is stopped... the only thing that moves is the space itself... I could do that just with the space through the light projection. The light approaches... the tunnel gets progressively more lighten, for example...

Interestingly, while reflecting on the idea of exploring light as a means to change the station's atmosphere, Dylan starts to consider the possibility of making an animation for the project's final presentation. Grace responds positively to this proposal, but immediately raises a concern regarding time management:

GRACE

Yes, a sort of animation. But we have to... you don't have much time right?

DYLAN

Right. And now that is bothering me a bit. But okay.

The exchange above leads to an explanation by Grace about managing the design process:

GRACE

But that is also why this project is important. You have to learn to manage your reaction time and learn how to do something very important which is to balance our expectations. Because it happens all the time, you have thousands of ideas and you can see the final images, but then there is no time to execute them... the problem is not developing great skills but realise our limitations.

DYLAN

Okay. Great! Thank you!

Here, Grace is making the meta-design discourse completely explicit for Dylan. She details and summarises what aspects of the design process he is exercising (and hopefully learning) with the current project, and she articulates these ideas in an obvious and concise manner. This verbalisation is another example of the teacher making explicit what the student should be learning with his studio experience.

This was a moment when the teacher was not only expressing her reflection on the process but trying to convey it directly to the student. Dylan's immediate reaction was spontaneous and enthusiastic, but he did not build on what Grace said. Instead, he went back to work, and the interaction ended.

Design conversation 1.9

Dylan approached the teacher as she wandered the studio. While both are standing, he presents a few pictures he had made of the model.

DYLAN

What do you think?

GRACE

Now you are going towards (giggles) an abstract kind of... but yes, but you can do it anyway! ...but do you understand what I mean? We are already –

DYLAN

A bit far ahead?

GRACE

The next exercise in the project deals with the perception of space and bodies beyond the visual... maybe then... but do it anyway!

What Dylan showed Grace were some experiments with lighting and short frame-by-frame animations. We have seen how Grace had encouraged him to experiment more and, towards the end of the last interaction, Dylan was enthusiastic about that idea. However, now Grace wonders if the student has taken his exploration too far.

DYLAN

I should do this experiment anyway?

GRACE

Yes, but be mindful of the conclusions you are going to derive from this experiment.

DYLAN

I already... I can already see some... actually...

GRACE

That's the most important part.

When Grace urges Dylan to be mindful of his experiments, she is expressing the importance of learning with the process, that is, his explorations are only as good as what he learns from them “[t]hat’s the most important part” she concludes.

The teacher leaves the student at his desk and continues wandering the studio. Some 40 seconds elapse, and Grace returns to Dylan’s desk and finds him sitting still and staring at his model. He appears to be reflecting.

GRACE

So, you are completely lost?

DYLAN

I’m thinking... I need to... the problem is time but...

GRACE

Just go on with the experiments you mentioned.

DYLAN

Yes, yes.

Grace encourages him to go on. At this point, the session is nearly over, and the next interaction will be the last.

Design conversation 1.10

During this interaction, Grace and Dylan discuss the photos of the model that Dylan's should select for the final presentation. Dylan approaches Grace with his selection and says:

DYLAN

For instance, here in this perspective I transmit more the sense that there is a station here. There is more liveliness in this photo then the other. But that's it! I had to do this in order to reach this conclusion.

The last phrase shows that Dylan is reflecting on his choices and previous work. The "that's it!" is not a eureka moment in the sense that he solved a specific problem, but rather Dylan is expressing his understanding that he had to go through a process of trial-and-error to reach his conclusion. Dylan is reflecting on his design process. His thinking follows the format of *I had to do this to understand that*, a sign that he is considering how the sequence of design moves have changed his initial formulation of the project.

The interaction proceeds with a discussion of the photos for the presentation and ends shortly after. The transcript above was the only example of the student expressing awareness of his design process. It is perhaps significant that this happened towards the end of their interactions; we will elaborate on the findings on the next section (discussion.)

Design language summary tables

Next, we coded both participant's verbalisations according to our design language model. The model offers a general description of the language of design, focusing on its dual nature (the meta-design discourse and the design grammar). The main objective is to identify how prevalent design language is in the teacher-student interactions (or if it is even present at all).

In the last section of the findings, we present a summary table of the design language used during the conversation including both meta-design discourse and design grammar.

The examples are extracted from the context in which they occurred, and therefore less meaningful. Nevertheless, the tables function as a reference point and help organise the information. The tables are sometimes accompanied by a comment that calls attention to results that stand out.

Meta-design discourse tables

GRACE (TEACHER) META-DESIGN DISCOURSE		
Transcript	MDD Category	Verb.
<i>Maybe it is a bit irrelevant if you find the answer to that question or not.</i>	Eva.	9
<i>...a certain height which allows you to have more space to experiment more things... do you understand what I am telling you?</i>	Mov.	17
<i>Yes, yes... You can even explore... yes, it's more interesting for your exploration because you end up having the same height...</i>	Mov.	33
<i>Imagine that the light... that you go beyond the reality that it's represented totally here right?</i>	Ref.	34
<i>But what I am suggesting is: what you have here is the model of a real situation right? So, you take advantage of your model (Rep) and... let's imagine that your project was to manipulate lighting in order to completely change the subway station (Ref). You take advantage of your model to show it. You manipulate the light and colour to change the whole atmosphere of the space.</i>	Rep. Ref.	37
<i>The whole platform? Maybe... you have to think about what you want to do (Eva)... but imagine that you also had to intervene in the tunnel (Ref)... for example, have you noticed the new pt-blue station in Lisbon? Have you noticed, they seized the station using only light and colour. Every time the subway enters the station it turns blue... so, imagine that you were going to intervene in the tunnel using only light and colour (Ref)... perhaps the lights turns on in specific moments...</i>	Eva. Ref.	39
<i>It seems to me that you are too focussed in representing reality (Eva), which is also important because you end up learning to control a series of tools (Lea)... but add to that an explorative side (Mov)...</i>	Eva. [Lea.] Mov.	40
<i>Yes, a sort of animation. But we have to... you don't have much time right?</i>	Man.	44
<i>But that is also why this project is important. You have to learn to manage your reaction time and learn how to do something very important which is to balance our expectations (Lea). Because it happens all the time, you have thousands of ideas and you can see the final images, but then there is no time to execute them (Man)... the problem is not developing great skills but realise our limitations.</i>	[Lea.] Man.	45
<i>Yes, but be mindful of the conclusions you are going to derive from this experiment.</i>	[Lea.]	48
<i>Legend:</i>		
Ref: reformulating; Rep: representing; Mov: moving; Eva: evaluating; Man: managing; Lea: Design learning		

Table 23: Grace's meta design discourse

The teacher refers to all five aspects we identified as core design activities (see the design language model in chapter 2):

- Reformulating 3
- Representing 1
- Moving 3
- Evaluating 3

Managing 2

Design Learning 3

The category of *design learning* emerged from the analysis of this study. During the study, we often observed the teacher clarifying what the student should be learning from his experience. These explanations are connected with the unfolding of the project and of the design process as well.

Besides referring to all of the core design activities, also notice that the teacher often makes connections between them, that is, the teacher reflected on the impact a *design move* had for the *reformulation* of the project:

Yes, yes... You can even explore... yes, it's more interesting for your exploration because you end up having the same height. (Mov)

Imagine that the light... that you go beyond the reality that it's represented totally here right?(Ref)

Or how an evaluation might lead to a design move:

It seems to me that you are too focussed in representing reality (Eva), which is also important because you end up learning to control a series of tools (Lea)... but add to that an explorative side (Mov)..

It seems that the teacher is aware that different design activities can influence each other to a great extent. Let us now look at the student's meta-design discourse table:

DYLAN (STUDENT) META-DESIGN DISCOURSE		
Transcript	MDD	
	Category	Verb.
<i>For instance, here in this perspective, I transmit more the sense that there is a station here. There is more liveliness in this photo than the other. But that's it! I had to do this in order to reach this conclusion (Mov).</i>	Mov.	52

Legend:
Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;
Lea: Design learning

Table 24: Dylan's meta-design discourse

Dylan's only meta-design discourse was an expression of a reflection on how his sequence of *design moves* lead him to a new understanding.

Design grammar summary tables

GRACE (TEACHER) DESIGN GRAMMAR		
Design Grammar Category	Transcript example	Count
Representation	<i>Work from a top-view perspective [12]</i>	10
Configuration	<i>So, here you can get more depth (...) a certain height which allows you to have more space to experiment more things... [16-17]</i>	5
Composition	<i>But then you won't explore this space here [32]</i>	5
Basic geometry	<i>(...) just the basic dimension, so that you have a volume [4]</i>	4
Materials	<i>Of course, the light that you actually see is not completely white is it? [52]</i>	3
Attributes of form	<i>Every time the subway enters the station it turns blue [39]</i>	3
Context of use	<i>(...) so, imagine that you were going to intervene in the tunnel (...) [39]</i>	2
Part of artefact	<i>as if it was the pit...of the rails right? [24-25]</i>	2
Structure	<i>(...) and you support this here. [22]</i>	1
Precedent	<i>(...) for example, have you noticed the new pt-blue station in Lisbon? [39]</i>	1

Table 25: Grace's summary of design grammar use (verbalisation between brackets).

In the report we saw how Grace insisted that Dylan should primarily focus on his model; this is reflected by the design grammar analysis revealing the category of *representation* (that refers to denotation tools such as sketches or models by which elements of the design are represented) as the most prevalent in the teacher's discourse. This insistence correlates with the student's design grammar results also focussing on the category of *representation*.

DYLAN (STUDENT) DESIGN GRAMMAR		
Design Grammar Category	Transcript example	Count
Representation	<i>I have more cardboard... And then okay, I was thinking of cutting an opening here. Erhm... and then build a cone [25]</i>	14
Configuration	<i>The ratio of the subway varies a lot according to the relation of the line. [9]</i>	4
Attributes of form	<i>then it could be just a matter of filling the tunnel inside with another colour [40]</i>	3
Materials	<i>Let's say, the tunnel itself would reflect the light [41]</i>	2
Type of artefact	<i>And it also varies from subway to subway [7]</i>	2
Basic geometry	<i>I wasn't sure I wanted to work that merely as a cube and this way maybe I can move one of the facets[4]</i>	1

DYLAN (STUDENT) DESIGN GRAMMAR		
System	they develop the subway lines in such a way... there are several systems [7]	1
Context of use	for example, in high demand lines in certain cities [7]	1

Table 26: Dylan's summary of design grammar use; verbalisation number between brackets.

The table below compares both participants design grammar results (we highlighted the stand-out result in grey):

GRACE & DYLAN DESIGN GRAMMAR COMPARISON			
Domain	Sub-domain	Count	
		<i>Grace</i>	<i>Dylan</i>
Form	Basic geometry	4	1
	Attributes	3	3
	Composition	5	-
Function	Purpose	-	-
	Usability	-	-
	Fruition	-	-
Materialisation	Materials	3	2
	Structure	1	-
	Operation	-	-
	Configuration	5	4
	System	-	1
Human Factors	Ergonomics	-	-
	User requirements	-	-
	Cost	-	-
	Sustainability	-	-
Communication	Connotation	-	-
	Denotation	-	-
Representation		10	14
Program		-	-
Context of use		2	1
Artefact	Type	1	2
	Part	1	-
Precedent		1	-
Total		36	27

Table 27: Design grammar comparison

4.1.5 Discussion

We will now examine the results identified in the description of events. We begin with a general analysis of the conversation and move progressively to a description of the actual design teaching and learning process in detail.

From a quantitative perspective, the dialogue was almost equal (see the verbal output table). Teacher and student talked a similar amount of time, and we observed both participants alternate in initiating their short conversations. However, the transcripts show that the student's discourse was less fluid, at times incoherent, and also less assured. Dylan often hesitated, for instance:

Yes perhaps that's what... yes, that's it... because I couldn't even find this. I couldn't find this information... I wasn't sure I wanted to work that merely as a cube and this way maybe I can move one of the facets...erhm...and regarding...and regarding...

On the contrary, the teacher's talk is coherent and purposeful, she is consistently clear in her speech, whereas it was at times difficult to understand the ideas behind the student's discourse.

A possible explanation for the difference in speech is that the student finds himself in a vulnerable position. Waks (1999) observed that novice design students "can be expected to experience feelings of loss of control, vulnerability and enforced dependence." (p.310). Student's insecurity is to some degree expected since the student's work is ongoing, that is, in this case study, Dylan is not presenting a final project that has gone through several moments of review and development. In other words, it is not a finished product, therefore it is likely that Dylan still felt unsure about his project and how to talk about it. We witness the student struggling with his process, trying to find the words to express doubts he cannot, at the moment, formulate clearly.

The teacher, on the other hand, is in a completely different position. Her role is to guide the student through the design process until he resolves the project. Furthermore, besides a successful project, she was concerned if the student was learning from this project experience. These concerns were expressed with a type of meta-design discourse that emerged from the analysis of this case study; we categorised it as *design learning*, which is an explicit statement regarding what the student should be learning from his project experience. The teacher expressed concern with the student's design learning three times:

It seems to me that you are too focussed on representing reality, which is also important because you end up learning to control a series of tools.

also here:

You have to learn to manage your reaction time and learn how to do something very important which is to balance our expectations

and finally:

Yes, but be mindful of the conclusions you are going to derive from this experiment.

These moments are similar to what Adams, Forin, Chua, & Radcliffe described as breaking the 4th wall to create a teaching moment (2014), that is, a moment during design conversations when the content-specific teacher knowledge is made clear and visible for the student. It will be interesting to see if we observe this type of discourse emerging from our next case studies as well.

Concerning our main guideline – the language of design – the transcripts show that the language of design was continuously used by both participants during their dialogue. This observation was expected since past studies had already presented similar conclusions (Goldschmidt, 2002; Marda, 1996; Schön, 1983). However, this study had a particular standout result: while teacher and student registered a high count for design grammar (teacher 36 and student 27), the teacher expressed a much higher frequency of meta-design discourse (15 to 1).

Our first deduction about this result derives from the understanding that the participants have different roles in the dialogue, and the teacher plays more than one part in the interaction, Goldschmidt (2002), for instance, enumerated three (namely: source of expertise/authority, coach or facilitator, and the instructor as ‘buddy’), while Schön stated that the teacher alternates between demonstrating and describing (1987), that is, between being in the role of a traditional teacher, explaining and letting the student learn on his own, and being a design-studio coach, or an expert designer, demonstrating how to design and expecting the student to learn by imitation. Fleming (1998) suggests that these roles are at times conflicting since the teacher must react to students’ work without actually resolving it for them.

But regardless of how we categorise their role, the design studio places teachers in the complex situation of having to both teach the student about designing, and occasionally demonstrating how to design themselves (Sachs, 1999). It was therefore expected that Grace found it useful to verbally express her thinking about the design process (whether referring to her demonstrations of designing or to the student’s). In other words, the teacher was simultaneously showing the student how to design and telling the student about designing, which help explain the higher frequency of meta-design discourse on her part. The teacher

has the responsibility of making the design process more clear for the student while guiding him during his attempts at designing. These tasks naturally propel the teacher's talk towards moments of reflection about the student's project. It was her job to stop and reflect on the action of designing.

Students, on the other hand, do not have the same explicit necessity to express the thinking that supports their process of designing. Furthermore, their main concern is with their project, that is, students are engaged with the project at hand, they are working to finish on time and have a good grade. Therefore, it is expected that Dylan's discourse focused on operational aspects and practical concerns about his design, which could explain his focus on design grammar elements. Concerning this issue, Fleming (1998) warned about the role of the design tutor in "helping [the students] be more assertive, more rhetorically astute, and less tied to the concrete objects in front of them" (id, p. 62), and we indeed observed Grace encouraging the student to take a step back from the concrete object at hand and think more globally on a couple of occasions:

Maybe it is a bit irrelevant if you find the answer to that question or not.

and

It seems to me that you are too focussed on representing reality (...) but add to that an explorative side

Besides the emphasis on keeping a broad perspective, Grace, at times, appeared to be trying to stretch the student's perspective, effectively broadening the scope of possibilities he could explore. These moments were signalled with the expression "imagine that", and correspond to the reformulating category of the design language model, that is, a moment of reframing of the project's boundaries.

Imagine that the light... that you go beyond the reality that is represented totally here right?

and

So, you take advantage of your model and... let's imagine that your project was to manipulate lighting in order to completely change the subway station.

and

so, imagine that you were going to intervene in the tunnel using only light and colour

These transcripts suggest that, for the teacher, the project at this stage has unstable boundaries. Grace constantly questioned the student's

current focus, wondering if there might be other solutions, suggesting different points of view that might alter his current understanding of the project. She seemed completely at ease with the unstable nature of the design process, while the student was more eager to commit to a direction.

A different explanation for Dylan's almost complete absence of meta-design discourse is that the student is a novice struggling to learn, understand, and effectively apply a way of thinking, working, and speaking. Additionally, it is arguable if the student acknowledges the value in making his process explicit and reflect out loud about it. His concerns are more practical than reflective. Therefore a focus on design grammar instead of meta-design discourse was perhaps expected.

Nevertheless, Dylan did exhibit a moment when he stopped and reflected out loud on the act of designing:

But that's it! I had to do this in order to reach this conclusion.

According to our design language model, this statement can be considered as an expression of a 'reflection on the act of designing', Dylan is stating that he had to go through many experiences to reach his conclusion. A reflection that follows the format of *I had to do this to understand that*, in other words, the student stops and considers where his sequence of design moves had led him.

This statement was spoken in the final moments of the design conversation, which raises the question if the teacher's consistent displays of reflection on the design process throughout the interaction influenced the student's statement. To establish a definite causal relationship would be premature, but we should carry this insight and see if it is repeated in future studies. For now, we observe that – the single exception notwithstanding – the student did not verbally express reflection on his design process.

We should be clear that we are not stating that the student did not reflect on his design process at all; while we did not observe the student expressing these issues it does not mean he did not give them any consideration or thought. Some studies have shown that when directly prompted to report on their process students are capable of doing so (Christiaans, 1992; Goldschmidt & Rodgers, 2013) but these techniques (such as the 'learner reports' used in TU Delft) are conducted a posteriori, therefore they do not demonstrate that the student can activate this capacity during the actual process of designing. Furthermore, Uluoglu (2000) suggested that the most important premise in teaching design is to let the student understand that design is a conscious and self-aware activity.

It is essential for students to be able to articulate their design process. An ability to express meta-design discourse is not only a way to communicate with the teacher but crucially with oneself. To be able to stop and think about the design process as it unfolds is to be in control. The ability to, at any moment, pause and reflect about the project is crucial to assess it, to consider other possibilities, to make room for exploration. We observed Grace repeatedly reflecting on the design process and Dylan following on her lead. The teacher was showing the student how to do it, offering a thinking template for him to use.

Good practitioners are reflexive and self-aware of their way of working. A designer that is unaware of his process seems counter-intuitive (Schön, 1987). In fact, we have the example of the teacher in this study, who consistently expressed reflections about the design process during this conversation. If this pattern repeats in the following case studies (i.e. teachers scoring high on meta-design discourse and students low), then it suggests that there is a gap between the understanding of one's design process between experienced designers and novices. This is to some degree expected, but we also expect to see an evolution from novice students to graduate level students in terms of design language fluency.

However, we should keep in mind that it is possible that some students might have a visual way of reflecting on (and presenting) their design process, that is, even though a student may not verbalise his process he could still be able to express it via a sketch, a diagram, or a model for instance.

An alternative explanation for the higher frequency of coding for design grammar (registered in both participants) is the nature of the briefing: the students were challenged to work with a predefined space that did not correspond to a real setting. In other words, it was a simulation; there was no actual context to interact with. This is not an uncommon exercise for novice design students, abstract briefings are meant to make the students experiment with form, construction, geometry, or colour, without the constraints of a real-life setting (Boucharenc, 2006; Kocadere & Ozgen, 2012; Wallschlaeger & Busic-Snyder, 1992).

As such, in our case-study, Dylan was developing a subway station that had no connection to the real world of public transport, or to any specific city or line. It was a 'generic' subway station. The exercise is constructed to encourage the exploration of space, light, colour, and textures; it is, therefore, unsurprising that the coding revealed a high frequency of design grammar references.

However, while both participants registered similar design grammar frequency, there was a qualitative difference between the uses. The main difference was that Grace more often established connections between

design elements combined with a constant overview of the whole project. For instance:

But what I am suggesting is: what you have here is the model of a real situation right? So, you take advantage of your model and... let's imagine that your project was to manipulate lighting in order to completely change the subway station. You take advantage of your model to show it. You manipulate the light and colour to change the whole atmosphere of the space.

Light and colour are introduced according to their impact on the atmosphere of the space. In this example, the design elements are not referred separately from the whole context of the project.

The student also demonstrated an ability to make connections between design domains, particularly during the beginning of the interaction. Goldschmidt, Hochman, & Dafni (2010) observed the same occurrence in their studies where the statements made at the beginning of a conversation by the students included more issues raised than subsequent ones. Goldschmidt et al., suggest that this is the case because the student's are presenting reflections conducted before the conversation; which also seemed to be the case with the student in this case study.

Furthermore, the teacher also made connections between design grammar and meta-design discourse, with both aspects often being linked in her discourse. The teacher's alternate use of design grammar and meta-design discourse suggest a mastery and control (a fluency) of the language of design we did not observe in the student. This, of course, confirms our expectations and is an important point to be confirmed in the next set of case studies.

Visual design representations as mediating artefacts

On the subject of visual design representations, we can state that the dialogue was to a great extent mediated by the scale-model. The conversation was divided into ten different interactions, and the scale model was only absent once (the first interaction) and even so not entirely since the teacher ended the first interaction suggesting that Dylan should focus on the model more.

It is important to mention that the students were working on a briefing that instructed the use of a space with fixed dimensions; more importantly, the brief stated the students had to use a scale model as the primary working tool for experimentation. As such, the scale model was a mandatory presence as the central visual design representation.

We did not observe the use of sketches or drawings of any kind, and in the last interaction instead of the physical model the student used photos he

had taken of his scale model.

It is clear from the observations that the presence of the model was determinant for the student's project and influenced the development of the interactions since it became the main focus point and reference between both participants. This is consistent with studies that suggest the importance of VDRs as shared mental models between participants in design meetings (Goldschmidt, 2007).

On one of the occasions (design conversation 1.6), the teacher sat next to the student at his desk and made a direct intervention on the model. She demonstrated her ideas by manipulating the model directly with her hands while she talked; during this interaction, both the teacher and the student's discourse became elliptic and hard to follow. In this segment, words such as "here," "this," "that," "this point," were repeatedly used; these words support the teacher's explanation and take a secondary role to what the teacher is demonstrating. Schön made a similar observation in his notorious case study of Quist and Petra (Schön, 1983), where the author noted that the teacher's discourse becomes obscure during sketching, and that his words only make sense when connected with the drawings (in the case of our study, the model.)

While the model was always present, teacher and student varied in the way they approached it. Grace insisted that the model should be used to explore different ideas, whereas the student (for a long while) had a more instrumental approach. The teacher made it clear that the student should use the model for more than just a representation of reality:

Imagine that the light... that you go beyond the reality that it's represented totally here right?

and

It seems to me that you are too focussed on representing reality, which is also important because you end up learning to control a series of tools... but add to that an explorative side

It was clear that the teacher used the model like she would use a sketch: to experiment, explore, test ideas and examine the results immediately. The student took some time to understand this, but after the teacher used the model to illustrate her point the student seemed to shift and adopt a more explorative approach. Curiously, the teacher then had to be sure the student was not taking his exploration too far:

Now you are going towards (giggles) an abstract kind of... but yes, but you can do it anyway! ...but do you understand what I mean? We are already...

Taxonomy of teacher-student interactions

We have seen how the preferred term in the literature for teacher-student dialogue in the design studio is the 'crit'. However, we noticed (in chapter 2) that the term is not used consistently. We are fairly certain most authors would consider Grace & Dylan design conversation as a series of short desk-crits, as it is usually defined (Dinham, 1987a; Goldschmidt et al., 2010). However, we did not notice an emphasis on 'critiquing' by the teacher, which some authors consider to be the fundamental element of a 'crit' (Dannels & Martin, 2008; Oh, Ishizaki, Gross, & Yi-Luen Do, 2013; Utaberta, Hassanpour, Che Ani, & Surat, 2011).

Instead, Grace & Dylan's interactions could be more accurately described as a working dialogue between teacher and student, an informal conversation that can take place anytime during the studio session, and in which a formative approach predominated over an evaluative one. Also, we observed that during the design conversation the student's project evolved considerably, which reinforces the idea that the interactions analysed in this case study were focused on the project at hand, with both participants designing together.

This description is consistent with what we named as a series of *desk tutorials*. The distinction between a desk tutorial and a desk crit, while subtle, is significant. A desk tutorial is short, often spontaneous, entirely formative, and focussed on a design project that changes as a result of the interaction, a desk tutorial describes the everyday conversations in a design studio; whereas a desk crit is more focused on assessing the state of the project than working on it, it is more formal, less spontaneous, with a definite beginning and ending. However, these categories are not hermetic, Schön's (1983) case study, for instance, is an example of a design conversation that fluctuates between a desk crit, a review, and a desk tutorial.

Finally, it is worth noting that the participants began with different approaches to the design. The teacher was consistently explorative, often reformulating the boundaries of the project, and always comfortable with both the unstable nature of the design process and the early stages of a design project. The teacher alternated between evaluating, reformulating, and moving, with each of these design activities influencing each other. On the other hand, the student was more tentative, insecure, and eager to remain within a specific framework. However, while teacher and student began the conversation with different approaches, we observed the student gradually adapting his approach to match the teacher's; namely by moving from a rather limited exercise to a more explorative one, efficiently moving from stable boundaries to embracing an unknown and unpredictable design process.

4.1.6 Conclusions

The main finding of this study was that the student did not (with one exception) verbally express meta-design discourse during the design conversation. This finding stands out when compared with the teacher who often used meta-design discourse with a variety of purposes. Moreover, we observed the teacher alternating her feedback style (from using more verbal explanations to a more demonstrative role) and neither way elicited the student to verbally express his design process. Therefore, from this case study, we conclude that an analysis of the design language revealed the teacher's design process (shown clearly in her verbal discourse) but not the student's.

The second highlight concerned design grammar. While there was no substantial difference between teacher and student in quantitative terms, the teacher expressed design grammar in an integrated way by making connections across design domains and keeping an idea of the whole project, whereas the student tended to focus on one area at the time often losing track of how it related to the larger whole.

The three-dimensional model was a focal point throughout the design conversation. The model anchored the teacher-student dialogue and kept the dialogue focused on the project. We identified a significant difference in the participants' approach: the teacher insisted the model should be used to explore ideas, while the student began with a more instrumental attitude. With the teacher's insistence, the student moved from thinking of the model only as a maquette to using as a thinking-sketch; that is, he explored and tested solutions, experimented with different points of view, and used the model to think and work through possible solutions.

Finally, during the design conversation, we observed the student's project evolving. With each interaction, we saw multiple design moves being enacted, as well as several evaluations and reformulations of the overall understanding of the project's boundaries. In the end, the project was different from where it had started, and as the project evolved so did the student's design process, which became less instrumental and one-directional to more explorative and open-ended.

4.2 Case study 2 — Ella & Janis

“As if you’re making your line of thought visible.”

4.2.1 Study background

INTRODUCTION

The studio class we observed is a part of the first year of a design course of a public architecture and design university in Portugal.

The design studio (usually called *project*) is the critical part of the course, with the class occupying the majority of the students’ time (there are three sessions of four hours per week). It is also the course with most academic credits. With slight variations this is a typical setting for a design studio course with the *project* or *design studio* typically occupying the centre of the design course.

This undergraduate design course takes three academic years to complete. Afterwards, the students can join either a product or a communication design master course. The three-year undergraduate course is, therefore, a general design course, aiming to prepare the students in the foundational aspects of design before they embark on a more specific disciplinary study (in product or communication design).

BRIEFING

The briefing does not refer to a specific context (whether real-life or fictional). It is an exercise intended to make the students experience a design project in a more explorative and abstract way than would be possible if they had to consider a particular context of intervention. These types of projects are often a part of a semester or one year long *foundational* or *basic design* courses; briefings of this kind are typical in first-year design courses. The pedagogical purpose is to progressively introduce the process of design to the students without overwhelming them. Additionally, this sort of exercise has been a traditional way of making students explore the creative potential of using geometric rules to develop new forms (Boucharenc, 2006).

The briefing combined two-dimensional and three-dimensional design. The overall theme is the exploration of modules as the generating elements of form (in both two and three dimensions). The students learn to create geometric matrixes based on a single two-dimensional module

as well as three-dimensional structures supported by the repetition of a single three-dimensional module.

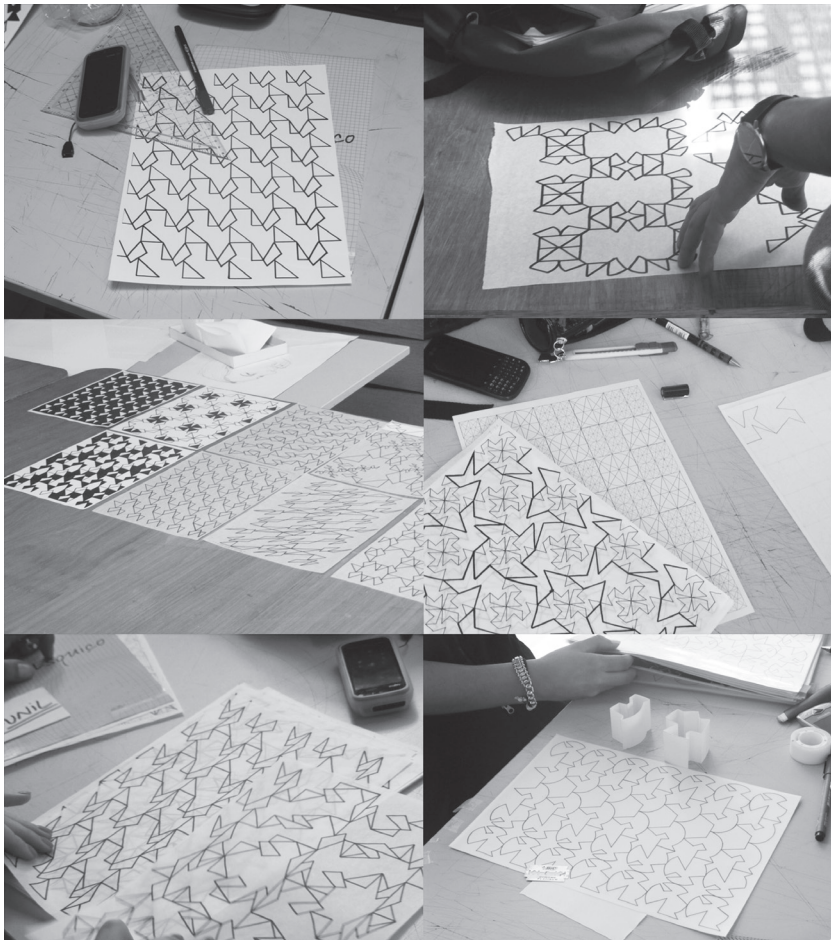


Figure 8: Sequence of the students' work: sign, matrix, and 3D object.

The project was separated into stages that evolved from creating a two-dimensional sign to developing a family of signs, followed by patterns based on a selection of signs, and finally, a three-dimensional object (without function) that could both structure itself and be self-sustaining.

Between each stage, the students were challenged to make choices and decisions that had a direct influence on the next phase of the project. To illustrate the briefing we will present a sequence of images of the work the students were developing during the sessions: from sign to matrix, to

three-dimensional object. During the observations, most students were working on their matrixes, but some were already moving on to the three-dimensional model.

STUDIO CONTEXT

There were supposed to be thirty-four students in the class. However, the students were rarely all present at the same time – several of them arrived later, others settled on their desks for a while but eventually left the studio, and some never arrived at all. Our impression was that the number of students continuously present in the class was closer to twenty or twenty-five during both sessions. Furthermore, some of the students present in the first session were not present in the second and vice-versa. Also, the students who were present during the sessions often left the room,⁸³ which made it difficult to keep a precise number of the students that were in the studio.

This is not uncommon in a design studio class. Students often arrive late or miss one of the studio classes during the week. The studio class takes up a considerable amount of hours, and while class frequency is controlled and mandatory, the design studio is understood more as the students' working space than a traditional university lecture hall. That is, while the students might miss a couple of design studio sessions here and there, it is also true that they meet at the studio and work during hours outside of their appointed schedule.

The sessions that we observed took place a couple of weeks before the project's final delivery and presentation. Thus, there was an imminent deadline influencing the sessions, so the students kept engaged with their projects throughout, while the teacher (Ella) repeatedly referred to the approximation of the deadline.

The studio was an open-plan room with a wall of top to bottom windows that allowed daylight to fill the space. The opposite wall separated the studios from a workshop (where students spanning all course years and different courses construct their models and prototypes). The students mostly sat at their desks, which were displayed in a 'U' shape with the teacher's desk at the top.

PARTICIPANTS

The class was conducted by a single teacher (to which we assigned the pseudonym 'Ella') that is responsible for the day-to-day tutoring in the

⁸³ Students often left the room to eat, make phone calls, meet a friend in the hall, and so on; which is consistent with authors that argue that the design studio is primarily a social place (Dannels, 2005; Wang, 2010) and this author's own experience as a tutor in a design-studio.

studio as well as the final evaluation. Ella is primarily a full-time teacher and academic, but she also has some experience as a professional designer.

The students were novices in the second semester of their first-year courses. We observed two sessions on two different days. Each session lasted approximately four and a half hours. The table below summarises the overall context of our observation.

SUMMARY

CASE STUDY 2 – CONTEXT	
Context	Design studio class
Course	Design
Course year	1 st year / 2 nd semester
Project	Graphical signs and 3D model
Participants	One student (Janis) One teacher (Ella)
Number of students present in the studio	Twenty-five
Course duration	Two months

Table 28: Case study 2 – context

4.2.2 Research questions and guidelines

For this case study, we are interested in observing if there is a repetition of the main insights that emerged from the previous case study, namely:

1. What is the result of design conversations?
 - Do design conversations reveal new knowledge about design and designing? If so, to what extent do students reveal they have apprehended it?
 - Do design conversations influence the design project?
 - Do design conversations influence the student’s design process?
2. What is the role of design language in design conversations?
 - Does the design language model reveal the design process of teachers and students and render it more explicit?
 - What are the differences and similarities between teacher and student use of design language?
3. How do the defining features of the design studio influence the

dialogue between teacher and student?

4.2.3 Methods and procedure

METHODS

As was the case with the previous study, we followed the overall methodology presented in the first section of chapter 3.

OBSERVATION PROCEDURE

Ella alternated between sitting at her desk and wandering around the studio approaching the students while they worked on their projects. There was also, at times, considerable noise due to the many students simultaneously present in the studio. However, the sound never seemed to disturb the overall working atmosphere, in fact, both teacher and students appeared to be used to it.

The interactions between Ella and the students developed similarly to the case study we presented before, with most of the teacher-student interactions being short conversations. Ella often wandered the room, observing, making brief comments, holding short conversations with the students, and offering guidance.

DIFFICULTIES

The higher number of students present in the studio (compared with case study 1) meant that the teacher had less time to dedicate to each student, resulting in shorter interactions.

RATIONALE FOR CASE STUDY SELECTION

This case study follows the design conversations between Ella and Janis. We highlighted Janis's case because she was the only student that registered more than one (relevant) interaction with Ella.

There were two interactions between Ella and Janis, and both took place during the same session (session 2). The two interactions can be considered one long conversation interrupted in the middle instead of two independent design conversations because (1) the conversations took place within the same session and with a short interval between them, and (2) clearly, the participants pick up the conversation where it left off.

Therefore, similarly to case study 1, Ella & Janis will be designated as *design conversation 2* of this research, which is subdivided into design conversation 2.1 and design conversation 2.2.

4.2.4 Results

FINDINGS – CASE STUDY REPORT

We will report the results following the same reporting method of the previous study, that is, we will present the teacher-student interactions in chronological order following a narrative structure.

Before moving on to the interactions, we will begin by presenting a complete table of the verbal output (table below) that includes the verbalisations and word count of the participants. This table functions as an introduction to the observations and provides an overview of the dynamics of the design conversation.

Verbal output

TOTAL VERBAL OUTPUT				
Teacher /student	Verbalisations	Words	Mean words/verb.	Word percentage
DESIGN CONVERSATION 2.1				
Ella (t)	18	447	24,8	68,6%
Janis (s)	18	204	11,3	31,4%
DESIGN CONVERSATION 2.2				
Ella (t)	16	289	18	55,7%
Janis (s)	17	230	13,5	44,3%
Total				
Ella (t)	34	736	21,6	63%
Janis (s)	35	434	12,4	37%

Table 29: Total verbal output

The table shows that the teacher talked more than the student, particularly during the first half of the conversation. While the number of verbalisations is practically equal (34-35) the teacher, in fact, registers an overwhelmingly higher percentage of words spoken than the student (63% – 37%). We have a dialogue where both teacher and student talked a similar number of times, but the teacher spoke much longer than the student.

Furthermore, the table also reveals that the two parts of the conversation had a different dynamic: in the first part, the teacher talked much more than the student, whereas the second part was more balanced.

Description of events

Design conversation 2.1

Ella and Janis's conversation begins with Janis (the student) approaching the teacher's desk holding a folder. The folder contains the patterns Janis has been working on. Janis opens the folder and both teacher and student flip through its pages examining the patterns one at the time. Janis is the first to talk:

JANIS

I've done one like this, and another one like this... and I think this one is nicer. But now I've done so many, but they all seem the same!

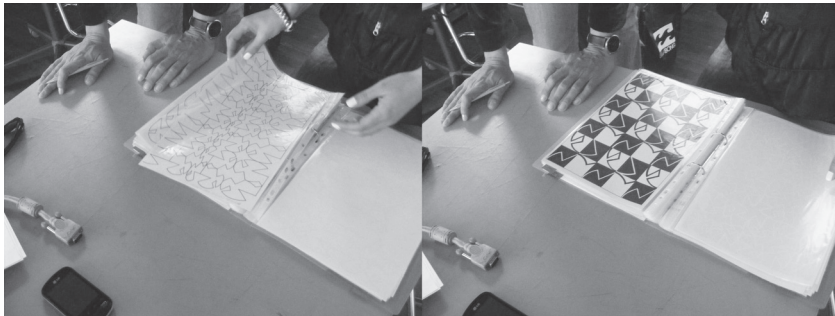


Figure 9: Janis presents her work.

Janis starts describing the work she developed so far, but how does she introduce her project? Notice how, while displaying the patterns, Janis also reflects about her preferences “and I think this one is nicer” as well as how many she has completed “(...) but now I’ve done so many(...)” and how she is having trouble distinguishing between them “(...)but they all seem the same!”.

Janis is reflecting on the current state of her project, she has made several patterns but is having trouble moving forward because she cannot decide which ones to choose. During her reflection she innumerates a series of issues but does not reflect about each one of them; in other words, she can identify a problem (all the patterns seem the same, which makes the selection difficult) and what the design moves that lead to it (she has done a lot of work) but this reflection does not, at this point, help her make a decision and proceed with the project. Janis's evaluation of her project does not lead anywhere; if all her patterns seem the same, how can she decide which ones to choose? The student appears to be stuck, unable to decide and proceed to the next stage of her project.

Notice also that it is Janis that establishes the topic of the conversation.

She does not address Ella with questions such as “what should I do now?” or “do you think this is ok?” but rather she introduces a pertinent and reflected difficulty⁸⁴; thus, while we gather from the verbal output that the teacher spoke much more than the student it was nonetheless the student that determined what the conversation would be about. Janis actively searched the teacher’s counsel with a specific doubt.

Let us now consider the teacher’s reply and how the dialogue unfolded from there:

ELLA
How about... you'll have to select six.

JANIS
Mm-hmm

ELLA
How about you spread them all around, and figure out what you want to do with all this work?

JANIS
Okay, I can do that.

ELLA
Maybe then they won't seem all the same anymore.

JANIS
Maybe.

ELLA
Maybe you'll be able to figure out some criteria for your selection. Maybe you'll become more pleased about the work –

JANIS
Yes...

ELLA
– and make a decision and move on. Deal?

JANIS
Deal.

ELLA
Okay then, spread it!

The teacher realises that the crucial issue concerns the process of

⁸⁴ It is our experience that novice students tend to present their work with either “what do you think?” or “what should I do now?” type of questions.

selection. The briefing encourages the students to generate and explore many alternative patterns, only to require – at the end of this phase – to select a final six. Ella suggests that Janis should spread her patterns on a large table; this advice is connected to the realising that the folder is not an adequate medium to make comparisons and choices between graphic patterns. As we can see in the picture above, the folder only allows examining one pattern at the time. A large table permits the student the overview perspective she lacks at the moment, which in turn facilitates direct comparisons between her patterns.

With her advice, Ella is showing the student how to look at her work differently. This looking is both literal and figurative; the teacher is giving a direct (literal) advice *spread the patterns on a large table*, but she is also encouraging Janis to adopt a broader perspective on her work.

There is also another observation emerging from the segment above: when Janis approached Ella she appears somewhat dissatisfied with her work, and so, in her reply, the teacher underpins her feedback with words of incentive “Maybe then they won’t seem all the same anymore (...) Maybe you’ll become more pleased with the work (...) and make a decision and move on”.

Following this exchange, the interaction is interrupted. The teacher leaves Janis to allow her time to display her work. Ella then proceeds to wander the studio, talking with other students here and there, while Janis takes all the patterns she had stored in her folder and moves to a large communal table situated to the side of the studio.

At this point, we noticed something interesting; while Janis prepared her work on the table, some of her colleagues became curious and approached the table to see what she was doing.



Figure 10: Janis spreads her work on a large table

This interlude takes approximately seven minutes, after which Ella comes by the table. The teacher re-starts the dialogue with some light-hearted and self-referential humour:

ELLA

Ah, you really spread it! You acquired the competence of spreading. Good!

The teacher then stands next to the student and they both observe the patterns in silence for a while.



Figure 11: Janis and Ella observe the student's patterns.

After a while, Janis describes how she organised the display of patterns:

JANIS

So, this is one sign; over there it's the other one, and here we have a combination of both.

ELLA

Yes? Okay then, how are we going to make a selection then?

JANIS

Okay.

ELLA

Tell me.

Ella immediately brings back the issue of Janis having to make a selection. Janis seems surprised and unprepared to answer, but Ella insists that the student should explain how she is going to decide. The student then explains:

JANIS

Some of them... well, first of all, I decided not to do anymore, because I think some of them if I just explore the negative version as well as changing the density they might be interesting. For example this one, or this one... now, some of them I'm sure I really like. And others seem very plain, or very similar... I don't know...

When pressured to explain, the student puts forward a short reflection about her design process, even though, again, the reflection is not far-reaching. Nevertheless, Janis introduces the issue of deciding not to make any more patterns; she explains why and gives a few examples that illustrate her point. After evaluating the current state of the project she concluded that a few variations on the patterns she already done will be enough.

Also, notice how the move to a larger table altered the conditions of the design conversation. First of all, it became less private (some colleagues approached and observed while Ella and Janis talked); but crucially, the conversation became more evaluative, since both participants were now assessing the project, not working on it. This aspect is more relevant when the teacher reinforces that the student must justify her choices, implying she will be evaluated on her decision making later on.

Ella is not satisfied with the fact that Janis used the phrase "(...) some of them I'm sure I really like (...)" as an argument for her decision making and asks her if that is her only criterion:

ELLA

But is the criterion here just “I like/don’t like”?

JANIS

No, it’s also...

ELLA

So? What is your criteria then?

JANIS

Hmm...

ELLA

What is supposed... what does the briefing say?

JANIS

It’s supposed to have –

The teacher responds to Janis’ indecisiveness with a sequence of questions, all aimed at clarifying what her criteria for selection were. However, the student is unable to answer, Ella then brings up the issue of the briefing, Janis starts to answer (hesitantly) when the teacher interrupts her to say:

ELLA

To summarise, it says you must choose six that are representative of your work; following notions such as order, contrast, rhythm. So. When we look at all this work, you either function by elimination or selection...

JANIS

Exactly.

ELLA

Or you can function by selection and elimination at the same time. By saying “this one I’m sure I want to keep, and this one I’m sure I don’t.” So, if you start doing that, surely you’ll immediately select at least a few. And then some will remain to be selected... or eventually you’ll realize there are still some explorations you need to do.

Up until this point, Ella had been trying to get Janis to reach her own conclusions, that is, she did not provide any concrete answers for the student; yet, during this moment, Ella interrupted the student and gave an answer to her question about the briefing.

In the transcript above, there is no moment in which Ella makes either a choice or a decision, or even expressed any preference whatsoever

concerning Janis' work. While the teacher has apparently taken control of the dialogue and she is, in fact, answering her question, it is nonetheless relevant to observe that what Ella is doing is presenting a sort of template of how to think and make decisions. She showcases what kind of criteria the student can use and how, which is to say, she is giving Janis the tools to be able to think for herself, and consequently decide for herself. Additionally, the teacher insists that Janis should express these decisions and choices with clarity.

In short, the teacher demonstrates how to think and reflect about the design process; how to make decisions that are well structured and argued, and she is showing her the vocabulary she could use; in other words, Ella exhibits how the student can pause the process of designing (and in this case in a stage of the project in which it is crucial to stop and make choices) and reflect on the path that brought her to that point and how she should conduct her decision-making. But the problem remains to be solved; Janis still needs to make, and justify her choices.



Figure 12: Janis begins to justify her choices.

JANIS

For example, I think this one here, it shows contrast, it has some larger and smaller ones... and a certain order. Since it is more or less geometric. This one I also like the contrast...

ELLA

It doesn't have to be exactly like that [points to the briefing] it has to follow those criteria of course, but your selection must above all be representative of

all your exploration, of your ideas, of the possibilities of surfaces that you explored. It has to tell a story through those six selections. Allowing that an outsider can understand that a surface can be explored in different ways. So, this one stays you say. What else?

JANIS

I also like this one. But I would also like to explore it further, whether with different densities or negatives.

ELLA

And then you have different degrees of complexity right? That's also a criterion, for instance there we understand there are many different geometric operations... but we can also start from step one; you must also consider if it makes sense to show the simplest surface as well. Because it marks the beginning...

The conversation unfolds with the student highlighting some of her possible choices; Janis tries to justify her decisions with some of the criteria suggested by the briefing (such as contrast, order, and different densities). The dialogue settles in a back and forth dynamic, that is, the conversation is no longer guided by the teacher.

The last segment of the first part of the conversation begins with Janis making a question:

JANIS

The surfaces must have a hierarchy between them?

ELLA

They should tell a story. If that's what you call a hierarchy...

JANIS

Yes, okay... (smiles) As if it was an evolution?

ELLA

Exactly, as if your making your line of thought visible. Even if you change it afterwards. You either make an intuitive "like/don't like" kind of selection, and then you begin to understand what underlies the "like/don't like", that actually there are other criteria that guided your choice... or you go the other way around, and you realise what distinguishes these surfaces and what should be selected or not. But what is essential is that you have the ability to make a decision, which is the

most important decision in this exercise.

JANIS

Yes, I know.

The interaction ends with another somewhat lengthy explanation of the teacher. Similarly to what we have observed above, Ella offers Janis a template for her thinking. The teacher suggests how the student can guide her selection, by mentioning that she can even start intuitively by choosing her preferred patterns – without using explicit criteria – suggesting that later she might realise that, in fact, there is an underlying order supporting her preferences. This way, Ella opens the door for a more intuitive process. But Ella also suggests the exact opposite approach, that is, that she can also first establish some criteria and then carry on with the choices; curiously, Ella never expresses a clear preference for either one or the other procedure. What she is in fact doing is demonstrating how the reflection on designing might unfold, not how it should unfold, the teacher leaves it for the student to decide how she will conduct her thinking.

The first half of the conversation ends here. Janis remains at the table examining her work and making choices. Later in the day (almost at the end of the session) Janis had achieved considerable progress; she had made her selection and moved on to developing her three-dimensional module and structure.

The second half of the conversation (design conversation 2.2 that we present next) captures the moment when Janis is starting to work on her three-dimensional structure. In this stage of the project, the students are required to work with physical modules based on the graphic signs that served as a basis to create the patterns.

Design conversation 2.2

The second interaction between Ella and Janis had a distinct character from the previous one. Their communication begins with Ella approaching Janis' desk as she worked on one of her three-dimensional modules.



Figure 13: Janis works on her model.

ELLA

Ah, you're already working on your model –

JANIS

Yes, okay, because I've already noticed that...well... I was considering which surface is better suited for...

ELLA

You don't have to use them as the floor-plan of your structure. It can or not be used like that... it can also be a side view...

Janis placed some of her chosen patterns on the desk, and the remaining she stored in the folder we had seen at the beginning of the first interaction. According to the briefing, these patterns, or matrixes, are supposed to support the creation of a tridimensional structure, which has to be built using a single module. At this point, Janis has already developed two different modules and is trying to figure out how she can use the patterns as the generating concept of a tridimensional structure.

Notice in the transcript above how the dialogue is anchored on practical issues concerning the development of an artefact – in this case, a tridimensional model – and therefore, both participants are focused on specific topics, namely what type of perspective to use (floor-plan or side view).

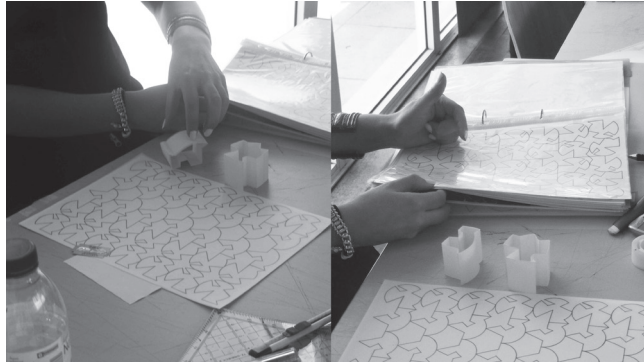


Figure 14: Janis explains her project.

At this point, the teacher highlights the differences between a two-dimensional and three-dimensional module:

ELLA

That is, the module has a certain two-dimensional behaviour but it can, and probably is, quite different in 3D. Because it has that extra dimension.

JANIS

And also in terms of consistency.

ELLA

Yes. Don't forget that there is also the weight –

JANIS

Exactly. For example I...in this case...well I already began working with cardboard in order to understand what is the easiest way to assemble the modules.

ELLA

Yes okay.

Teacher and student set into a back and forth rhythm, comfortably building on what each other said, they seem to have formed a mutual understanding. Notice that in the last segment, Janis expresses a short reflection on her process when she says: “(...) I already began working with cardboard to understand what is the easiest way to assemble the modules”, the student was experimenting with cardboard by making small versions of her 3D module and joining it in explorative structures to see if it stood. Therefore we witness Janis expressing the reasoning behind a design move (experimenting with cardboard).

JANIS

erhm, but for example, with this one I thought I could use rotation; but with this one maybe... well, it has more points of contact.

ELLA

Yes, yes it has.

JANIS

So this one maybe I won't rotate it... I would simply built it straight. But for example if I use this one... both this one... or... yes, this one I would just built it straight up. Because if this is the floor-plan I think I can make it stable.

ELLA

It is not a bad starting point to consider that one of your surfaces can function as a floor-plan that generates the whole volume. But you can also release yourself from that idea, and just state that there is a 3-dimensional module that because it has that extra dimension it also acquires a new freedom and new possibilities. But also new constraints, namely regarding the constructive process.

JANIS

Yes (hesitates)

ELLA

With the three dimensions you have the problem of the constructive process and the fact that the structure must be self-supporting, it structures itself.

There are a couple of issues worth noticing here. Firstly, the dialogue continues to unfold with both participants taking part constructively, and none of the parties determining the course of the conversation; in other words, the dialogue evolves naturally around the development of the student's model.

Secondly, we observe Janis' begins to hesitate about which of the two modules is more suitable to build the model: "So this one maybe I won't rotate it... I would simply build it straight. But for example, if I use this one... both this one... or... yes, this one I would just build it straight up (...)" in this moment of hesitation Ella becomes predominant again. Here the teacher gives a step back and offers an overview; she explains that Janis could continue with her starting point, or she could explore an entirely different option. Ella suggests, for instance, that Janis could start from the module itself instead of being so focused on the patterns.

The teacher then returns to design grammar issues when she reminds the student about the constraint of the structure having to be self-supporting; thus we observe that Ella is alternating between meta-design discourse and design grammar, linking both aspects in her speech.

How does the student react to this exposition?

JANIS

Yes, yes. But for now, from what I have done, it would start with these two. Or this one as well... with this one I like it that I could probably make it rotate.

From the excerpt above, Janis seems to try to bring the conversation back to a practical level: “Yes, yes. But for now, from what I have done, it would start with these two”. In the previous segment, we saw the teacher trying to challenge the student with alternative ways of approaching the project, with Ella suggesting that Janis could work from the module instead of the patterns. The student’s reaction seems to be to go back to the safe territory she already knows, that is, for now, she appears to prefer to work with what she already has done.

Ella does not insist. Instead, the teacher returns to a back and forth kind of dialogue; she highlights that the three-dimensional module structure is different from the two-dimensional patterns (which had a 5x7 module structure instead of a 3x3x5 one). Furthermore, it is important to note that both teacher and student are in turn handling the modules as they speak (see picture below) using it to highlight what they are explaining verbally.



Figure 15: Ella and Janis examine the model.

ELLA

Notice that now you have $3 \times 3 \times 5$. Okay? So it's not this.

JANIS

Mm-hmm So it would be this?

ELLA

Exactly. And then five.

JANIS

Mm-hmm So my idea would be –

ELLA

Five which is another... it's either that the structure is always straight...

JANIS

Yes, for example with this one I was thinking –

Janis understood the difference regarding structure; the student was about to elaborate on her thinking when she was interrupted by Ella:

ELLA

But you don't have to do many. You only have to make one model.

JANIS

Yes...

ELLA

You can try many. But you only have to make one.

JANIS

Yes, yes. But these are just hypotheses for now. For example if I make this one I could use it as a floor-plan and then I rotate it upwards.

ELLA

Yes, you can do that. And it doesn't have to be consistent. You can rotate the first level and not the second and so on.

JANIS

Ah, so I could create blocks and then it is the blocks that rotate.

ELLA

Yes. In that space of 5 upwards and then 3 anything can happen.

JANIS

Mm-hmm, okay.

At this point, teacher and student settle into a steady rhythm again, and Janis' understanding of the structure improves; the dialogue is here wholly focused on design grammar issues. Then, Ella introduces the question of the structure's weight again:

ELLA

Right? But you have to control more variables, the weight... the weight is highly relevant when you are thinking about a structure.

JANIS

Because the fact that there is this crossing between them...

ELLA

Yes exactly, that's good thinking! The fact that it rotates or not has to do with the module itself and the weight distribution.

JANIS

Okay.

Ella does not bring any meta-design issues into the conversation again.

Janis seems to have grasped the essential aspects she needs to understand to start building her structure; the interaction ends at this point and the studio session shortly after as well.

Design language summary tables

ELLA (TEACHER) META-DESIGN DISCOURSE		
Transcript	MDD Category	Verb.
<i>How about you spread them all around, and figure out what you want to do with all this work (Eva)?</i>	Eva.	2.1 v.2
<i>Maybe you'll be able to figure out some criteria for your selection. Maybe you'll become more pleased about the work...</i>	Mov.	2.1 v.4
<i>To summarise, it says you must choose six that are representative of your work; following notions such as order, contrast, rhythm. So. When we look at all this work, you either function by elimination or selection...</i>	Mov.	2.1 v.13
<i>It doesn't have to be exactly like that (points to the briefing) it has to follow those criteria of course, but your selection must above all be representative of all your exploration, of your ideas, of the possibilities of surfaces that you explored. It has to tell a story through those six selections. Allowing that an outsider can understand that a surface can be explored in different ways. So, this one stays you say. What else?</i>	Mov.	2.1 v.15
<i>And then you have different degrees of complexity right? That's also a criterion, for instance there we understand there are many different geometric operations (Eva)... but we can also start from step one; you must also consider if it makes sense to show the simplest surface as well. Because it marks the beginning (Mov)...</i>	Eva. Mov.	2.1 v.16
<i>Exactly, as if your making your line of thought visible. Even if you change it afterwards. You either make an intuitive "like/don't like" kind of selection, and then you begin to understand what underlies the "like/don't like", that actually there are other criteria that guided your choice (Eva)... or you go the other way around, and you realise what distinguishes these surfaces and what should be selected or not (Mov). But what is essential is that you have the ability to make a decision, which is the most important decision in this exercise (Lea).</i>	Eva. Mov. [Lea]	2.1 v.18
<i>It is not a bad starting point to consider that one of your surfaces can function as a floor-plan that generates the whole volume (Mov). But you can also release yourself from that idea (Mov), and just state that there is a three dimensional module that because it has that extra dimension, it also acquires a new freedom and new possibilities. But also new constraints, namely regarding the constructive process. (Ref)</i>	Mov. Mov. Ref.	2.2 v.7
<p>Legend: Ref: reformulating; Rep: representing; Mov: moving; Eva: evaluating; Man: managing; Lea: Design learning</p>		

Table 30: Ella's meta-design discourse

The teacher meta-design discourse focusses on reflexions on *evaluating* (3) and *moving* (7), there is little representing or reformulating probably due to the nature of the briefing.

- Evaluating 3
- Moving 7
- Reformulating 1

Managing 0
 Representing 0
 Design learning 1

JANIS (STUDENT) META-DESIGN DISCOURSE

Transcript	MDD	
	Category	Verb.
I've done one like this, and another one like this... and I think this one is nicer. But now I've done so many, but they all seem the same!	Eva.	2.1 v.1
Some of them... well, first of all, I decided not to do anymore, because I think some of them if I just explore the negative version as well as changing the density they might be interesting. For example this one, or this one... now, some of them I am sure I really like. And others seem very plain, or very similar... I don't know...	Mov.	2.1 v.9
<i>Exactly. For example I...in this case...well I already began working with cardboard in order to understand what is the easiest way to assemble the modules.</i>	Mov.	2.2 v.4

Legend:
Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;
Lea: Design learning

Table 31: Janis' meta-design discourse

ELLA (TEACHER) DESIGN GRAMMAR

Design Grammar Category	Transcript example	Count
Structure	<i>With the three dimensions, you have the problem of the constructive process and the fact that the structure must be self-supporting, it structures itself. [dc 2.2 v.8]</i>	8
Composition	<i>That is, the module has a certain two dimensional behaviour but it can, and probably is, quite different in 3D [dc 2.2 v3]</i>	3
Configuration	<i>Notice that now you have 3 x 3 x 5. [dc 2.2 v9]</i>	2
Basic geometry	<i>for instance there we understand there are many different geometric operations [dc 2.1 v16]</i>	1
Attributes of form	<i>it's either that the structure is always straight [dc 2.2 v11]</i>	1
Representation	<i>You only have to make one model. You can try many. But you only have to make one [dc 2.2 v12-13]</i>	1

Table 32: Ella's summary of design grammar use; verbalisation number between brackets.

Structure emerges as the primary category. Which is unsurprising considering that the purpose of this phase of the project is to create a self-sustaining tridimensional structure.

JANIS (STUDENT) DESIGN GRAMMAR

Design Grammar Category	Transcript example	Count
Configuration	<i>but for example, with this one, I thought I could use rotation [dc 2.2 v.5]</i>	6
Structure	<i>Because if this is the floor-plan, I think I can make it stable. [dc 2.2 v.6]</i>	3
Attributes of form	<i>But I would also like to explore it further, whether with different densities or negatives. [dc2.1 v.15]</i>	2
Composition	<i>I think this one here, it shows contrast, it has some larger and smaller ones... and a certain order [dc 2.1 v.14]</i>	1
Representation	<i>well, I already began working with cardboard in order to understand what is the easiest way to assemble the modules. [dc 2.2 v.4]</i>	1

Table 33: Janis' summary of design grammar use; verbalisation number between brackets.

Configuration and Structure emerge as Janis' top two categories of design grammar.

ELLA & JANIS DESIGN GRAMMAR COMPARISON

Domain	Sub-domain	Count	
		<i>Ella</i>	<i>Janis</i>
Form	Basic geometry	1	
	Attributes	1	2
	Composition	3	1
Function	Purpose		
	Usability		
	Fruition		
	Materials		
Materialisation	Structure	8	3
	Operation		
	Configuration	2	6
Human Factors	System		
	Ergonomics		
	User requirements		
	Cost		
	Sustainability		

ELLA & JANIS DESIGN GRAMMAR COMPARISON			
Domain	Sub-domain	Count	
		<i>Ella</i>	<i>Janis</i>
Communication	Connotation		
	Denotation		
Representation		1	1
Program			
Context of use			
Artefact	Type		
	Part		
Precedent			
Total		17	13

Table 34: Design grammar comparison

4.2.5 Discussion

The discussion is structured around a comparison between the two halves (2.1 and 2.2) of the design conversation. The conditions that framed the dialogue between Ella and Janis shifted several times during their ongoing interaction, and as the conditions changed so did both the dynamic and the content (regarding design language use) of the conversation. We will examine the results with an emphasis on the connections between the conditions that framed the dialogue and the design language used by teacher and student.

Design conversation 2.1

Similarly to what we observed in case study 1, at the beginning of this study the student is stuck, Janis struggles to select the final graphic patterns which means she cannot progress to the next stage of her design project. *Stuckness* has often been observed in design students behaviour (Sachs, 1999; Christiaans & Dorst, 1992) and it is interesting to note that it is also what Schön (1985) first notices during his analysis of a teacher and student dialogue “[f]irst of all, perhaps, that [the student] has been involved in doing something on her own, and that she has gotten stuck”. (p.53)

Thus, the conditions that frame the beginning of the conversation were clear: the project is at a decision making stage⁸⁵; the student (Janis) has concluded her work and must choose the final graphic patterns

⁸⁵ Decision making has been described as a crucial step (or move) in the design process, particularly during initial stages of the project (Christiaans & Almendra, 2010).

to proceed to the final stage of the project. Considering these initial conditions with the assistance of the design conversations model, we can describe Ella and Janis' dialogue as it varies along the axis that defines the type of design conversation:

- The conversation is informal since it began spontaneously with Janis approaching Ella requiring feedback;
- It starts as a private conversation between teacher and student;
- The dialogue occurs towards the end of a project phase (the work is done, it is time to decide), but there are no mandatory deliverables.

These conditions point to a *desk tutorial* type of conversation; therefore we expected an informal, private conversation in which the student's project changes and evolves. However, let us consider how the conversation unfolded.

Janis presented her work with a short reflection about her process: she has made several patterns but is having trouble moving forward because she cannot decide which ones to choose. The student is aware that the difficulty lies in her inability to make a decision, but despite this awareness, she finds herself unable to proceed. Then, Ella suggests the student should move to a larger table and spread her work to be able to evaluate it and make a decision.

The teacher's recommendation had multiple effects in the conditions that initially framed their conversation: (1) it moved from a completely private to a semi-public conversation (several students gathered around to witness the dialogue); (2) it clarified the formative – evaluative axis by shifting the conversation towards an evaluative talk; and (3) it compelled the student to adopt an overview perspective of her work. Therefore, the design conversation between Ella and Janis changed from a desk tutorial (where it began) to a type of dialogue better described as a desk review, where both participants discuss and evaluate a particular deliverable.

These changes in conditions did not, at first, appear to facilitate Janis' decision making. As the student spread her work and examined it, she found herself still stuck and unable to decide. However, with the teacher's assistance, Janis began making comparisons between her patterns and trying to move beyond a *like/don't like* consideration of her work. Having established better conditions to enable an overview of the work, the teacher then helped the student by showing her how to compare her output, how to evaluate it and finally come to a decision. Crucially, Ella neither made a decision for the student nor presented a set of established criteria for decision-making; instead, the teacher gave examples the student could use to proceed. The teacher highlighted that the criteria and method of selection should be the student's responsibility, but the

student had to argue her reasons clearly, and her decisions should be consistent with her design process, that is, her final choice should not be random, but instead follow from and reflect her design process.

Interestingly, while this shift in conditions places the focus on the end product (the graphical patterns), the teacher was more interested in exploring the student's decision making and overall design process than in examining the graphic pattern's merits. In other words, the teacher is more interested in analysing the student's process than the project's results. During her feedback, Ella offered examples of how the student could conduct her choices, without actually making any decisions for her. Instead, Ella insisted that Janis should be able to express her criteria clearly, and her choices should make her design process visible, Ella explicit says: "Exactly, as if your making your line of thought visible." Cennamo & Brandt (2012) called this approach the right kind of telling (drawing the term 'telling' from Schön), in which the teacher "[t]hrough questioning and thinking out loud (...) modelled their design thinking and presented alternative ways of viewing design problems." (p.854)

Ella's assessment of Janis' work transcended an evaluation of the final result, or even a consideration of the student's current grasp of design knowledge, rather, the teacher persistently tried to make the student engage in dialogue, even during the more evaluative review. And yet, the imbalance of words spoken between teacher and student in this study was substantial (63% – 37% in favour of the teacher), despite the many efforts of Ella to make the student express herself clearly: "okay then, how are we going to make a selection then?"; "Tell me;"; "So? What are your criteria then?" or "What is supposed... what does the briefing say?"

Thus, it seems that one of the purposes of a design conversation is to get the student to speak. This is consistent with what Dannels (2005) found in her observations and interviews with design teachers: "the faculty viewed the functions of oral genres as more complex than teaching students design concepts or testing students on their knowledge of design decisions." (p.154). The author suggests that the purpose of the dialogue between teacher and student in the studio is to make the student enact the role of a designer, and this enactment also means mastery of how to present one's work and process. Therefore, the focus moves from an assessment of the project to an attempt to make the student engage in a performance "fundamentally recreating, reflecting, and shaping those communities and practices within which students learn to become disciplinary members" (id, p.157).

In a design conversation, the evaluation of the project (and also a consideration of the design process) requires an active role from the student, since the teacher cannot (or perhaps, should not) make decisions

for the student or reflect on the process for her. What Dannels and other authors⁸⁶ claim is that the design studio places the students on a stage where they can experience the role of being a designer. A fundamental part of the process of learning how to design is to experience it; it is, therefore, unsurprising that Ella restrained from solving the problem for Janis. This is also connected with what we know about the design process itself; there is no one correct way to proceed in a design project, the possible solutions are multiple and not always mutually exclusive. Therefore a designer must be prepared to make choices.

The question then arises of how successful was Ella in getting the student to enact the role of a designer.

We observed that Ella's attempts to make the student express her criteria were not met with an answer from the student. That is, there was little verbal engagement from the student during the first half of the conversation. It seems that Ella's insistence did not lead Janis to imitate her, the student does not build on the type of discourse that the teacher used. Janis listens to the teacher closely, and attempts, here and there, to compare her work and elicit criteria for her selection, but she does not elaborate or reaches any concrete conclusions. If she is reflecting on her process she is doing so *internally*, a situation that contrasts with the teacher's continual and eloquent verbal elaboration on the design process.

This observation confirms what we had seen in the first case study: the teacher often punctuates her talk with meta-design discourse, in fact, it is a type of speech that emerges naturally from the unfolding of her conversation. On the contrary, the student seems overwhelmed and rarely responds in the same way. It is the case of both studies that we found the differences in design language fluency between teacher and student quite striking.

The teacher left Janis examining her patterns, and the student's decision is made "off camera", that is, when we meet her again for the second half of the conversation she has already made her selections and moved on to the next stage of the project. It seems clear that the conversation with the teacher helped Janis to decide and move forward, even though she did not articulate the reasons that supported her choice. Thus, the conversation had an impact on both the student's process (it *unstuck* her) and project since a selection was made and the project proceeded to the next stage.

⁸⁶ (Ochsner, 2000) for instance, arguing from a psychoanalytic framework, suggests that the experience of acting the role of a designer in the design studio is crucial and should even be privileged over making the design process explicit for the student.

Design conversation 2.2

The second half of the conversation tells a different story. Janis was working on the initial stages of the final phase of her project. This phase requires that the students design a tridimensional self-sustaining structure based on the graphic patterns done previously. The constructive principle is the same, (the form must result from the repetition of a single module) but now Janis must apply this principle to a tridimensional structure. Thus, the project moves from a two-dimensional to a tridimensional domain, which renders its phases so distinct, that each one is almost a micro-project in itself requiring a new approach.

Therefore, the main characteristics common to the start of any design project are present: there is an indeterminate number of possible solutions or paths to follow; it is not completely clear what is the best direction to take; the constraints of the problem are not sufficient to determine the solution(s); and so on. These conditions describe a typical unstable design situation with the variables open for reformulation. Additionally, we can describe Ella and Janis' second half of the conversation as informal, formative, and private, and contrary to what happened in the first part of the interaction, these conditions remain the same throughout the dialogue.

The role of visual design representations in mediating Ella and Janis' dialogue deserves here particular consideration. We can identify two different situations: notice that, whereas in the first part of the conversation the student presented dozens of two-dimensional patterns for appreciation, the second part the conversation is focused on just a couple of tridimensional modules.

Teacher and student engage differently with both visual mediums. During the second part of the conversation, Ella and Janis often manipulate the 3D modules as they speak, and their conversation is connected to this direct engagement with the models. Furthermore, both participants focus on how to use the 3D modules to build a structure, and unsurprisingly their conversation predominantly addresses structural issues such as weight, points of contact between modules, extrusion, rotation along a vertical axis, distribution of modules, and so on. Thus, Ella and Janis' dialogue settled on a back and forth elaboration of structural issues.

A direct engagement (in this case: manipulating the model, turning it in their hands, raising it to eye level, pointing, experimenting different arrangements of modules, or quick structural tests) with visual design representations seems to coincide with a dialogue that settles on a practical, applicable, and operational focus, and a diminishing of issues regarding the design process. Ella and Janis' dialogue becomes closely connected with the manipulation of the model. We observed a similar

situation in case study 1 during the moments when teacher and student engaged directly with the student's model. In both cases, during direct engagement with the models, we saw quick rounds of short questions being raised and answered on the spot, that is, design moves are conducted swiftly even if not verbally explained (i.e. the participants avoid stopping the flow of the conversation to examine a design move).

We are considering the role of models in how they mediate teacher-student dialogue, how it affects the unfolding of the conversation; similarly to most aspects of the design studio this issue has seldom been observed and studied empirically in real-context studio settings. Nevertheless, some authors have argued that models can have a positive impact in enabling a productive discourse between teacher and student. For instance, McNair, Paretto, & Groen (2014) refer to an interaction "with artifacts serving as a generative tool for rich discourse" (p.28); while Gursoy and Ozkar (2015) stated that the manipulation of models during teacher-student interaction can enable "informed and resourceful conversations among students and between students and instructors." (p.49). In the case of Ella and Janis, we observed that close interaction with artefacts coincides with shorter and more operational conversation, with a prevalence of design grammar, and a back and forth, somewhat equal, dialogue between teacher and student.

Other authors have described how 3D models are particularly useful means to support the development of design ideas (Muller, 2001), and in a study conducted in a controlled setting (i.e. not in a design studio context) Charlesworth (2007) found that students that engaged directly with 3D models achieved better results than students working with virtual ones, while Ferguson (1977) stated that models had been used since medieval times when master craftsmen employed them to communicate complex structural parts during the building of cathedrals.

We are then faced with two different conversations. The first part was dominated by the teacher and focussed on meta-design discourse; while in the second part of the conversation, the student seems to be much more in control and confident, and both participants contribute to the discussion, which is marked by a discussion of design grammar issues.

The design learning category

In the previous case study, we observed the teacher often openly expressing what the learning outcomes from the student's design experience should be; we termed this type of (meta-design) discourse as design learning. One of the aims of this case study was to observe if the teacher used a similar speech as well.

We did not find it to the same extent, however, towards the end of the

first part of the conversation, the teacher explains that the exercise's most important aspect concerned decision making: "but what is essential is that you have the ability to make a decision, which is the most important decision in this exercise."

While we did not find any more uses for this type of discourse, it was interesting to see it repeated during the case study. This is a kind of discourse that is wholly contingent on the design studio educational setting; a concern with the learning outcomes of students seems to be a part, though not a prevalent one, of design teachers' discourse. The concern if design students are learning from project to project is shared by several authors (Quayle & Paterson, 1989; Valkenburg & Dorst, 1998) and so far the case studies indicate that design teachers are indeed expressing this matter during design conversations by being clear and explicit about the learning outcomes.

Eagerness to engage in dialogue

A final note on an insight that emerged from this case study concerns the student's eagerness to talk with the teacher. This observation adds to what we had already observed during case study 1: both Janis and Dylan (the student in case study 1) stood out from the observations because – unlike their colleagues during the sessions we observed – they were eager to search the teacher's feedback.

It was the student's will to experience a close design conversation that set this case study in motion. An eagerness to engage with the teacher could be a condition of a fruitful design conversation, particularly in unstructured sessions like the daily meetings of a design studio in which the teacher wanders the studio holding predominantly short conversations with students. Student engagement has been recognised as a significant influence on learning in higher education (in general). In a review of this topic, Kahu (2013) showed that the context (from a social-cultural perspective) could play as much a role in student engagement in learning as personal behaviour and psychological issues, in other words, student engagement is not solely dependent on a personal commitment to learning from the student. We should add that it was clear that both teachers (Ella and Grace from case study 1) seemed more eager to engage back with the students as well. After the students' initial approach, both teachers came back to follow up on the student's work (in case study 1 this occurred multiple times).

Finally, we conclude that the student's eagerness to work with the teacher seems to be decisive for a productive conversation to take place. We observed how the certainties (as well as the doubts) that students bring to the studio are dissipated by the teachers with a couple of questions (in

the case of case study 1) or just changing their current point of view (in the case of case study 2).

Thus, it seems clear that the more the student engages with the teacher in a conversation the more the project will change, and therefore the project experience will be more productive since project instability is a characteristic of professional design activity. A willingness to engage in conversation with the teacher renders the student's experience in the design studio closer to professional practice. Instability during the design process places the student in a vulnerable position, with fewer certainties, which is a context favourable to the questioning of design moves, reformulations of fundamental understandings of the design situation, and analysis of the design process.

However, it should be noted that while both students were eager to discuss the project with the teacher, this willingness to participate did not lead the students (in both case studies) to verbally reflect (significantly) on their design process during the conversations.

4.2.6 Conclusions

This case study reinforces the main finding of case study 1, namely that there is a substantial difference in the ability to verbally express a reflection on the design process between teacher and student. During the design conversation reported in this case study, the teacher frequently punctuated her speech with examinations of design moves and evaluations of the current state of the project. The student, on the contrary, did not express the same level of reflection on her process, even though the teacher insisted (with questions) that she should reveal her decision-making criteria and demonstrate an ability to evaluate her work and process.

It follows from the previous point that an analysis of the participant's design language reveals the teacher's approach to the design process but not the student's. The design conversation displays the teacher's expertise in design – which is made clear – but incidentally, the student does not make a verbal acknowledgement that she apprehended it. Therefore, one of the challenges of the design teacher seems to be, on the one hand, to lead the student to reflect on the design process, and on the contrary for the student to reveal it verbally. During the case study, one of the teacher's main concerns was to examine not only the end product but also the student's process, but this goal is hampered by the student's difficulty to express her design process clearly and continuously.

Another finding was that direct manipulation of three-dimensional models correlates (we have observed it in both case studies) with a more practical discourse by both teacher and student, in other words, considerations of

the design process diminish and a reference to aspects of design grammar become predominant. The student appears to be more comfortable with this type of conversation (when discussing more practical issues, Janis talked more often contributing almost equally to the dialogue) which reinforces the idea that students feel less comfortable discussing design process awareness than they do with more practical matters.

The results also suggest that an eagerness to engage in dialogue, on the part of the student, has an impact on the quality of the conversation: by quality we mean that the project evolves and the student's initial preconceptions of the design situation are altered, the process becomes unstable and multiple possibilities to proceed emerge. These characteristics bring the conversation in the studio closer to professional design practice, thus making the experience richer for the student.

Chapter 5

Graduates

5.1 Case study 3 — Albert & Paul

“You’re unravelling the ball of thread.”

5.1.1 Study background

INTRODUCTION

The studio sessions we report here were a part of a first-year master course in product design, and the meetings took place during the second semester. There was an increase in complexity, when compared to the previous case studies, since the project involves a real-life context. Thus, we noticed the design project moving from previous unrestrained academic exploration to an approximation of a professional challenge.

The class consists of about 16 students who are separated into four groups. The project is to design a system of public transport — specifically a tram line — for the city of Lisbon. The work alternates between individual assignments and group work: each group chooses a particular tram line, then, after a phase of on-site preliminary research, each student selects one area to work on and develops it individually before coming together again for a final integrated group project.

A particularity of this case study is that the studio has two teachers that share tutoring duties. Each one is present on a specific day of the week, but both are present for milestone presentations and reviews. Both teachers are professional product designers, work together in the same studio, and have been teaching design courses together for a while.

Therefore, the study background we present here is valid for both case study 3 (concerning Albert & Paul) and 4 (Robert & Patti).

BRIEFING

The briefing is entitled “Integrated Mobility System” and concerns the design of a public transport system for the city of Lisbon. The system includes a tram vehicle and all its associated infrastructure and services, namely the corresponding stops, shelters, and ticketing. Additionally, the students have to work with the currently existing tram lines, that is, they cannot develop new lines or alternative routes.

While the project is a controlled simulation, the context is entirely real. The student's projects are therefore anchored in the specific constraints and particularities of Lisbon (such as its hilly topography for instance). Thus, the student's intervention, while entirely fictional, is a simulation of a professional design project involving the citizens of a real city with its corresponding challenges.

The briefing introduces the students to the subject with a short overview of the contemporary problems of public transportation in a relatively large city, namely: environmental issues, public vs private means of transportation, traffic congestion, and so on.

The students are instructed to gather in groups of three to four elements. Each student has a particular part of the system to work on (vehicle or shelter for instance) which should be integrated into the final design system at the end of the project.

SUGGESTED METHODOLOGY

When moving into the study of graduate students, there was a notable difference we will address here. In case studies 3 and 4 the students were introduced to an explicit methodology that was communicated by one of the teachers (Robert) during a lecture.

The lecture was not integrated in the other sessions of the studio, that is, it was a lecture in all the usual ways except it was held in the design studio where students usually work instead of a typical lecture hall; other than that, it was an ordinary lecture with the teacher speaking and the class listening. Moreover, there was no mandatory reading list on design methods nor were the students required to show how they would implement this method in their usual working method.

Together with the lecture, the teachers included a written description of the suggested methodology alongside the document that presented the briefing. The part that concerned the method was titled "suggested methodology" in which the teachers describe five sequential stages; this methodology is connected to a schedule with deadlines and presentation dates. The duration of the project was four months.

Thus, the proposed design method proposed by the teachers is separated into a sequence of five design stages:

1. Research
2. Definition of schedule or plan
3. Concept studies
4. Development
5. Model and final presentation

1. Research

In this stage, the students are required to research products currently on the market and also study the product's history. Students are also required to analyse the social situation (target audience/characterisation of users) and the environmental impact of the topic under study. Additionally, there should be research on materials, technologies and ongoing research in the field.

Stage 1 ends with a presentation to the whole class.

2. Work plan

Stage 2 involves the elaboration of the project execution plan according to the deadlines, deliverables, and project needs.

3. Concept studies

During this stage, the students must develop concept proposals (two to three) for different ways of solving the problem. The concepts should be integrated with the system developed by the other colleagues in the group. By the end of phase 3, students should have an inspiration panel, visual references, and illustration of concepts with perspectives, functional area plan, and generic sizing.

4. Development

In this stage, students must select one concept to develop further, followed by concept testing by use of a study model of the chosen solution. Then, the students should develop the approved concept through three-dimensional modelling followed by the verification of regulations, technical, and ergonomic constraints.

After that, the students should work on the refinement of the three-dimensional model; develop a computer-assisted-design (CAD) version, and detail colour, materials, and finishes.

5. Prototype and final presentation

The project concludes with a final detailed prototype delivered with a descriptive memory report, and a final class presentation.

Other than the stage of research preceding the elaboration of a work plan, the method is a straightforward description of how a hypothetical design project unfolds. It organises the students' working schedule in a stable development line from conception to detailing to prototyping. However, the processes usually associated with design thinking are not addressed, nor are any references to moments of reflection and reconceptualisation, and of cycles of analysis and synthesis. Therefore, managing design thinking seems to be left for the students to manage on their own within

the general methodological framework provided.

In the conversations we report in case studies 3 and 4 both students are in the same stage of project development: phase 3 – concept studies, meaning that they have completed the development of research and the work plan and are now working on concept generation and development.

STUDIO CONTEXT

The studio is organised with the desks forming a U shape. Each session is scheduled to last five hours (from 8h30am to 1h30pm). There is a wall to the back and a blackboard to the front where the teacher's desk is located. The side is made up of top to bottom windows and a door that leads to a patio, while the other side separates the studio from the hall with a barrier of student lockers. The wall displays previous poster presentations of the different stages of the project.

The design conversations format is the *group review*. The teacher arrives and holds a meeting with each student semi-privately, that is, with the whole group watching. The remaining groups remain in their places preparing their presentations or working on their projects. There is only one review per student/group, that is, the sessions we observed were not ordinary working sessions with the teacher wandering the studio and offering feedback but instead structured review sessions the students had prepared in advance. This *modus operandi* was the same for both teachers.

Similarly to previous case studies, the number of students present in the class varied throughout the sessions. For instance, we observed that often the groups would disperse for a while after meeting with the teacher.

PARTICIPANTS

In this case study we will report the design conversation that occurred between Albert (teacher) and Paul (student), and in case study 4 we will follow Robert (teacher) and Patti (student).

SUMMARY

CASE STUDY 3 & 4 – CONTEXT

Context	Design studio class
Course	Master in Product Design
Course year	1 st year / 2 nd semester
Project	Public Transport System (tram) for the city of Lisbon

CASE STUDY 3 & 4 – CONTEXT	
Participants	Two students (Paul & Patti) Two teachers (Albert & Robert)
Number of students present in the studio	Sixteen
Course duration	Four months

Table 35: Case studies 3 and 4 – context

5.1.2 Study questions and guidelines

This case study follows the same guidelines as the previous case study.

5.1.3 Methods and procedures

METHODS

We observed several studio sessions. A couple of these classes were introductory lectures with no studio work. It was only after observing and recording several interactions with all the groups that we selected the case studies to analyse.

OBSERVATION PROCEDURES

We observed four sessions (two with each teacher). The first was the project kick-off that followed a lecture format in which Robert introduced the briefing, timeline for the project, and the criteria for evaluation.

The remaining three sessions were design studio sessions with the students working at their desks and the teacher holding meetings to follow the progress of the project. However, the sessions were more structured when comparing with the previous two case studies. The teacher held only one review session with each student after which he called the session over. This was the case with both teachers. All the conversations occurred in the context of a small group. Therefore they were semi-private, more informal than formal, but more formal than the one-on-one private conversations we observed in the previous case studies. There were no spontaneous conversations, with all the talks following a clear beginning middle and end.

DIFFICULTIES

Similarly to previous studies, the main challenge was to keep track of the sketching while taking notes about the conversations. Comparatively to prior studies one of the teachers – Albert – often sketched while talking with the students.

RATIONALE FOR SELECTION

We selected the two pairs based on the sequentiality, quality, and duration criteria we established before. The conversations we chose were the longest with the best quality of sound.

5.1.4 Results

FINDINGS — CASE STUDY REPORT

Verbal output

VERBAL OUTPUT				
Teacher /student	Verbalisations	Words	Mean words/verb.	Word percentage
Albert (t)	43	1405	32.7	66,3%
Paul (s)	44	712	16,1	33,7%

Table 36: Albert and Paul verbal output

Description of events

The conversation is longer than the ones we presented before. Therefore, we separated the interaction into different sections with sequential numbers and headings (1. *Tentative beginning*, 2. *Designing together...*). However, the different parts do not represent any real break in the conversation which unfolded in a single uninterrupted sequence.

The setting for this conversation is the following: Albert (teacher) and Paul (student) sat across each other on a large table. There were broad sheets of paper on the tabletop between the pair that contained sketches that Paul had already done illustrating his first ideas for the project. A couple of students that are a part of Paul's group sat to the left and right of the participants, these students observed the interaction, but they do not intervene and maintain silence throughout.

Differently from the previous case studies, the interaction did not occur spontaneously during an everyday studio session. Instead, the meeting is scheduled to follow the development of Paul's early ideas and preliminary research. The teacher expected to see first sketches or other forms of representation of initial ideas. Therefore, the design conversation can be considered a desk review: it is a semi-private encounter, and it is conducted in a semi-formal and evaluative way. Also, there are specific deliverables to examine (namely sketches of the student's first ideas).

1. Tentative beginning

The conversation begins with Albert, the teacher, sitting in front of Paul and asking:

ALBERT

Paul, what about you, can I see your work?

PAUL

So... I worked on maintenance, and cleaning, and the driver.

ALBERT

Those large sheets are great.

Paul tentatively begins by calling attention to some of the sketches he has done, while at the same time introducing the three issues he focussed on: maintenance, cleaning, and the tram driver. Paul's sketches are presented in A2 paper sheets, a choice of format that is praised by the teacher.

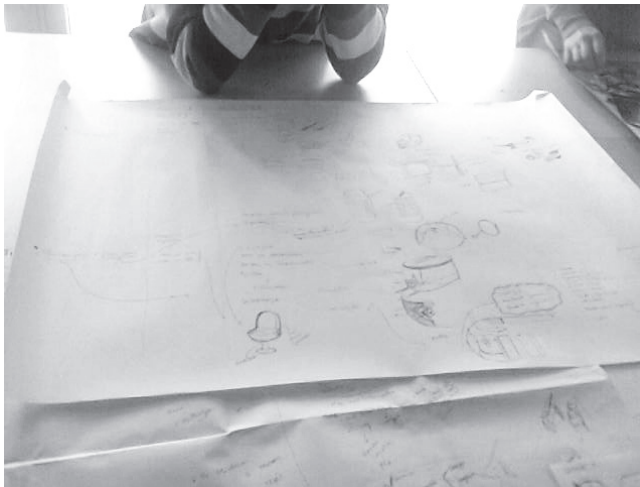


Figure 16: Paul presents his work in several A2 size papers.

The beginning of the dialogue is restrained by both participants. Neither teacher nor student seem interested in rushing into a discussion of the details of the project; in fact, both of them approach the project carefully, taking their time to talk while attentively surveying the sketches in front of them.

Concerning the teacher's comment, it is interesting to observe how the teacher is careful in his initial approach, that is, Albert did not immediately refer to any of the issues with which Paul introduced his project. Instead, the teacher contemplated the sheets and commented on them as an excellent medium to work with.

Then, Paul re-centred the conversation on the issue of maintenance:

PAUL

So, okay, concerning the maintenance there's a part here... right, that is... I have some doubts... I don't know a lot about parts... which parts have to be changed, which parts have to be accessible.

ALBERT

From inside?

Paul seems to be struggling with the results of his initial research into the problem. His discourse is slow and tentative, with many pauses to think while pointing to his sketches. The student expresses a lack of specific technical knowledge about maintenance parts. Interestingly, his concern is not with what the tram parts do, or what technology is behind their functioning, but how to access them; his point of view is focussed on how to access and replace the parts, this emphasis on accessibility is a typical product design concern. Paul's doubt is presented more like a reflection than an actual question or an assertion as if he is reflecting out loud about his work.

The teacher asks him if he means accessible from the inside, and Paul's reply continues in the same thinking-out-loud manner, in fact, in the next verbalisation the student is raising questions and answering them at the same time:

PAUL

From inside, yes. erhm... right, of course, maybe the electrical parts and the engine must be accessible. Okay, that's fine. But there's a certain unknown stuff that... otherwise....

ALBERT

uh-hmm... I will use again the same approach I used back there which is the issue of the bus, because maybe it is easier for me. Later, you'll have to analyse where all the stuff is in the current tram. But in a city bus, typically, you have something like this: maybe I'll do it again here, you have the little wheels and it has a flooring that is flat in some areas and normally raised in others.

Albert replies with a verbal explanation supported by a quick sketch of a top-view of a bus, a format he had already used during this session with another student: "I will use again the same approach I used back there (...)"

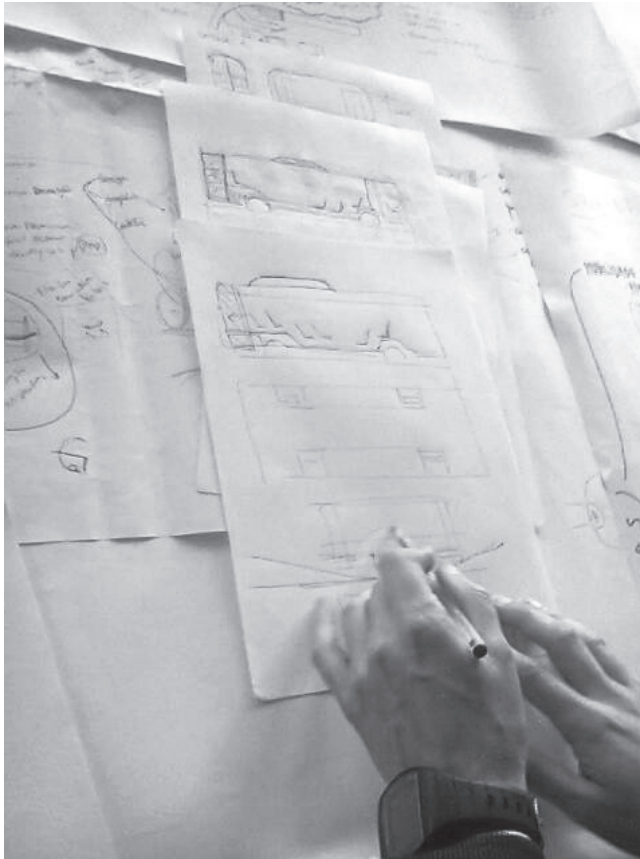


Figure 17: The teacher sketches.

The teacher introduces sketching as an element of communication between the two. During this segment, the visual design representation that mediates the conversation is no longer the student's initial sketches but the actual sketch (and the act of sketching) that the teacher is performing at the moment.

Albert is an expert in bus interior design. Therefore it is not surprising he would use his know-how even though the student's project concerns the design of a tram, the teacher indicates that the same organisational principles should apply to both vehicles. The teacher sketches throughout the whole segment transcribed above. His discourse is punctuated by references that only have meaning when related with the sketches they refer to ("something like *this*", "do it again *here*"). This type of discourse is even more clear in the next segment:

Yes, that is the... okay.

ALBERT

Right? And here I have the engine. And in other cases the engine is here. There. Sometimes there is also the gearing here... and instead of a window here the flooring is completely flat and here there are no seats or passengers.

PAUL

ah yes, yes, yes.

For the first time in our studies, we observed a teacher sketching during a design conversation. Notice how Albert's words become increasingly more referential to the drawing as if the sketch grew in importance and settled as the mediating artefact between the two. The "heres and theres" that punctuate the discourse of the teacher do not refer to the drawing itself (i.e. to the graphical marks on the paper) but to a virtual tram of which the sketch is a representation. Albert's sketch created a shared virtual setting that both can explore. Crucially, the sketch is an underdetermined communication medium, that is, it creates an undefined model, detailed only to the point of allowing the discussion of ideas, but not to the point of constraining the student's scope of solutions. The sketch is not the drawing of a specific tram; that is, it is not a settled solution, instead it functions as a template to experiment with general layout ideas.

It is also interesting to observe that the teacher's demonstration does not refer to any of the issues raised by the student. In fact, Albert's sketch and verbal explanation apply to the general layout of any public transport vehicle. Paul began with specific questions and issues, in reply, Albert elaborates on an overview of the interior of a tram; thus, the conversation reveals a contrast of focus and starting points. The student is concerned with specific issues he struggled with during his initial research, whereas the teacher downgrades the importance of these matters in favour of an overview perspective.

So far the teacher focused on general design issues of the tram, but in the next segment, his focus is shifted to the design process itself

ALBERT

What's the advantage? It is that when you raise this, you get seats here and on the sides, and people have to climb a step, and it's more complicated. Then, and that's why the side-views are so important, and that's why I was insisting on the floor-plan, when you use this view you see that the compartments of the wheels are wasted areas, right?

PAUL

Right...

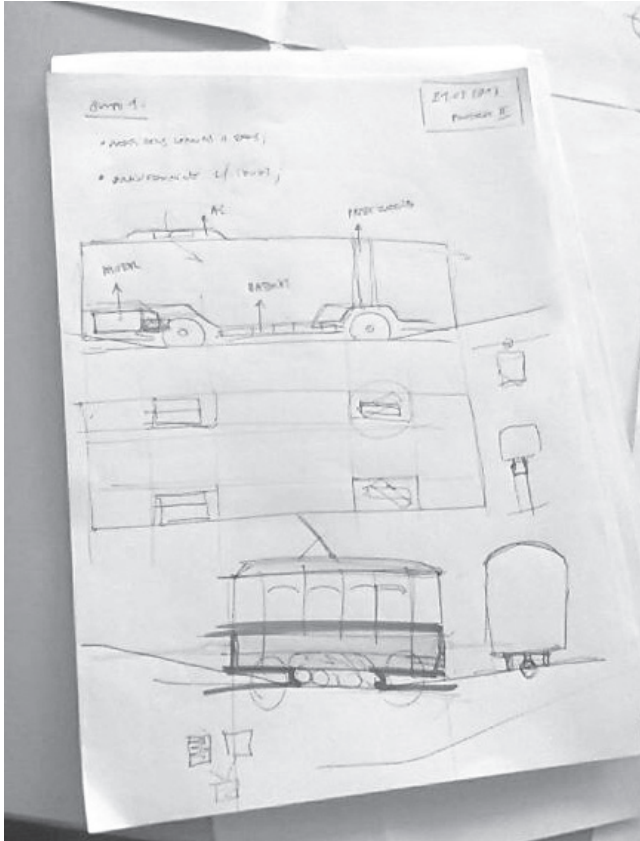


Figure 18: Albert's sketch.

In the above segment, the teacher reflects and emphasises the importance of using a specific type of drawing (namely side views and floor-plans) “then, and that’s why the side-views are so important, and that’s why I was insisting on the floor-plan(...)”. Albert proceeds to explain that this type of drawing allows the designer to *see* in a certain way; the verb to *see* is used also in the sense of *discern* or *discover*, that is, the designer draws in a specific way which leads him to investigate, to look into, to begin to understand a specific situation or problem; the teacher illustrates this point clearly when he says: “when you use this view you see that the compartments of the wheels are wasted areas, right?”.

The teacher is advocating the use of sketching to investigate, to explore, and derive conclusions. Furthermore, Albert is clear on what kind of

sketches (in this case side-views), how to use them, how to do draw them, and what kind of conclusions the student may derive from them. And the teacher does this by demonstrating himself while verbally explaining his actions to the student.

The teacher connects specific design issues (namely space optimization or layout design) with a reflection on the act of designing itself (what kind of sketches to use, how to use them, and how to use them to get answers and move the project forward, in other words, how to use sketches to carry out and evaluate design moves). Therefore, Albert combines meta-design discourse and design grammar in his speech.

With his intervention, Albert framed the conversation in an entirely different way from what had been the starting point of the student. The teacher established the boundaries in which the conversation would unfold, in other words, the teacher *framed* the dialogue. As we will see, the teacher's sketch of the tram's side views and floor plan became a central focus for the rest of the conversation.

Paul seems overwhelmed by the teacher's demonstration, and his reply is a hesitant "right..."

2. Delving into the project — or designing together

After this introduction, it is the teacher that centres the conversation from meta-design aspects back to specific issues of the student's project:

ALBERT

These are areas where in order to have a seat you must have something here... alternatively, the seat is higher again, and that's why you have all that stuff in the city bus, it's going around the technical stuff.

PAUL

But in the case... in the case of the tram...

Paul seems to be eager to transpose the teacher's example from a bus to the tram.

ALBERT

The case of the tram is a bit different. There, you have to consider that, and try to see in the photographs and go there again and observe it again and see where there are certain issues... why is the flooring so high?

PAUL

Mm-hmm.

ALBERT

What's going on down here. We don't really know but look...can we change it? If we change this architecture we might get there. Because it has a battery here...

The teacher refers to the interior organisation of the tram with the term “architecture”, an interesting use of the word almost as synonymous with space organisation, or layout. Albert suggests that for Paul to do an adequate transposition, he should go back to the field and observe for himself and then consider solutions for different layouts. From this point onwards it is clear that both teacher and student have moved on from the initial discussion and are now focusing on Paul's project.

The next segment seems to underline this shift; both participants are now delving into the project, reflecting, exploring hypotheses and possible solutions.

PAUL

Okay but then there is the issue of steep streets... which really -

ALBERT

There is the issue of steep streets and the issue of the way the wheels are set in order for it to turn with a short radius, right?

PAUL

There it is, okay.

Paul's “there it is, okay” signals the beginning of a mutual understanding between teacher and student. Both identify the same problem concerning the context of use of the tram; Paul is working on a line that operates in the city centre, a zone characterised by old streets that tend to be both steep and narrow. These contextual constraints establish limitations for the project. Paul's concern is recognised and expanded by Albert, which adds the aspect of the tight angle of many of the curves the tram will have to surpass.

In the following segment, Albert returns to the sketch he drew at the beginning of the conversation. He expands on it by drawing a few details, at this point the teacher is entirely absorbed by the project as if it was his own. Expanding on what they have been discussing, Albert draws and talks out loud about what he is doing:

ALBERT

And then there is here an issue of knowing that the tram must have an angle in the front, right? In order to be able to climb and go from ramp to ramp and another issue that includes, again, and again from a top-view,

you have to see where the wheels are, I'm not sure if they're not slightly more inwards than this -

PAUL

Yes.



Figure 19: The teacher illustrates his explanation with sketches.

The student remains silent during Albert's demonstration, he follows attentively but participates little. Again, we notice that Albert refers to the importance of the drawing "from a top-view, you have to see where the wheels are, I'm not sure if they're not slightly more inwards than this (...)". The teacher underlines the importance of using this type of views as a working tool to experiment and clarify issues. Almost in the same breath, Albert elaborates on what he means:

ALBERT

Maybe they are, but there we have it, I'm not worried about dimensions but I am worried in making a proportional drawing, generically proportional. In order to understand that it turns... here... and that it will have a certain path, right? In buses, the wheels are further apart and that's why they don't fit in certain areas.

PAUL

Right, and that does not happen with the tram.

The segment above centres on the importance of reflecting while designing, Albert is stating what he is thinking while he draws: "I'm not worried about dimensions, but I am worried in making a proportional drawing," which is an explicit reference to reflection during the act of designing. The teacher explains that, with this type of sketch, while the geometric rigour of specific dimensions is not essential, it is fundamental to keep a sense of overall proportion for the drawing to be useful. The teacher is reflecting out loud about his process and making it explicit for Paul.

Throughout this part of the conversation, the teacher is engaged with the project and conducting the conversation. This is so much the case that Paul's comment "(...) and that does not happen with the tram" goes completely unnoticed or is ignored. This part of the conversation reaches a natural conclusion in the following segment:

ALBERT

And so, when you think about this type of strategy you can then understand what you can do inside okay? It's that thing again: you just have to consider that here there are these large cubes... to you it won't be more than that... areas in which we later have to work on. This issue of having big stairs, maybe it's... important to realise why... if you change the electrical system maybe we can have smaller engines and then the access to it is somewhere else, and then what I was asking was, imagine, this all goes up and now it's this lid that opens... when you take it to the workshop that's where you mess with it (smiles).

The above transcript is the natural outcome of the teacher's overall demonstration, which was predominantly conducted with his sketch as a reference. Interestingly, Albert refers to the use of this kind of sketch as *strategic*, and how sketching enables to experiment with partial solutions.

The teacher mentions again that at this point the drawings can be quite generic as long as they are proportional, because the drawings will be detailed in future phases of the project: “It’s that thing again: you just have to consider that here there are these large cubes... to you it won’t be more than that... areas in which we later have to work on (...)”

3. And everything is here

The student seems a bit overwhelmed with the beginning of the conversation and the lengthy explanations of the teacher. In the next segment, Albert returns to the issues of maintenance and cleaning that Paul had used to introduce his project at the beginning of the meeting:

PAUL

Right...

ALBERT

So, you were saying...

PAUL

That aspect of maintenance.

ALBERT

That aspect of maintenance, yes.

PAUL

Which was the maintenance of... mechanical maintenance, as it were, replacement of parts and...

ALBERT

And the accessibility of those parts.

PAUL

Accessibility and replacement of... there, exactly, check-ups, that kind of stuff. And then, there is the issue of... cleaning, that is, there are two moments, let’s say two cycles... one is the everyday cleaning, and a total weekly wash-up or something... and then, I don’t know, annual check-ups.

The first thing to notice is that, in this segment, the participants are focused on the drawings that Paul presented. The dialogue is now driven by the student that finally manages to elaborate on his concerns about maintenance and cleaning. Notice that the teacher remembered that Paul’s focus was placed on the accessibility to technical parts.

The interaction proceeds with the teacher drawing again, but this time, on top of the student’s sketches.

ALBERT

That's logical. Then, maybe, can I make a doodle⁸⁷ here over your drawing? The issue of cleaning, that you mention there, maybe what you have to think about, at this moment, no matter what is going on underneath and the wheels, is that the tram in these areas here –

PAUL

Could have some curves (laughs).

ALBERT

It should have some curves⁸⁸ (laughs)...the seats should also raise like you did here.

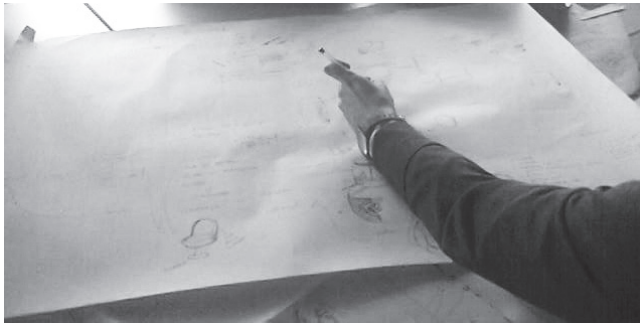


Figure 20: The teacher sketches over the student's drawing.

The *heres* and *theres* we underlined in the teacher's segment refer to the student's drawings, which are now mediating their conversation. It is interesting to note that Paul interrupted the teacher for the first time to complete his sentence (concerning the issue of the curves). Albert highlights the problem of raised seats by pointing to a different sketch of the student making full use of the large sheets and demonstrating he is keeping an overview perspective of all the partial solutions that Paul is presenting with his drawings.

The overall tone of the conversation is, at this point, of mutual-understanding and informality, with both participants smiling and being

⁸⁷ The teacher is whimsical and self-deprecating by using the expression "doodle" instead of "drawing" or "sketch", perhaps trying to ease his way around the sensitive issue of drawing over the student's sketch.

⁸⁸ Paul uses the Portuguese word "curvinhas" which is a diminutive of *curves*, and the teacher responds with the same expression. This is a Portuguese oral trait to which we could not find a similar expression in English; in this context it is used to lighten the speech, to make discourse friendlier. Alternatively, it can also be used to diminish and belittle. We think both student and teacher are adopting the former meaning and not the latter since they both smirked while discussing it and the conversational tone is light.

comfortable enough to make quips and word-play. In the following segment both participants seem to agree on the usefulness of exploring the solution of raised seats:

ALBERT

It really helps the cleaning.

PAUL

Yes, yes, yes, yes.

ALBERT

The seats could be attached to the side.

PAUL

Right, this comes a bit from the observation that...at the moment they're like this... and then it also has to do with the issue of the blind, of a textured flooring, if it would be easy to clean or if I would have to compromise.

ALBERT

Yes.

The conversation is now more focussed on particular parts of the project, whereas when the teacher was sketching and talking predominantly the talk was punctuated by meta-design discourse. Paul expresses concern about reaching a balance between making a textured floor (that would facilitate the use of the blind passengers) and cleaning (a textured floor could accumulate more dirt).

It is clear from the next segment that the conversation is becoming elliptic and challenging to follow for an outside observer, or for someone with access only to a transcript of the interaction:

PAUL

Of... this issue, which is that issue there.

ALBERT

But there could be. If, if -

PAUL

The material, right?

ALBERT

Yes, imagine, it doesn't have to be small spheres, because these are things with a very light relief.

PAUL

Yes, yes, yes.

ALBERT

Something like this, this is very easy to clean and it is a differentiated flooring that someone can feel, that there is something different, now, with a drawing like this you can immediately see that issue.

PAUL

Yes.

Albert and Paul are now debating possible solutions for the flooring considering the issue of its cleaning, and the teacher suggests a partial solution for the floor “something like this, this is very easy to clean and it is a differentiated flooring that someone can feel(...)”, building on the student’s initial concerns regarding cleanliness and inclusive design.

The discourse contains verbal references that point to specific issues that are visible in the sketches (“that issue *there*”, “something like *this*”). At this point, Albert refers back to the sketch he drew at the beginning of the conversation (“now, with a drawing like this you can immediately see that issue”), and again reinforcing that different types of drawing allow to experiment with different solutions. It is relevant to examine what Albert means by *seeing* in the sketch; Albert is speaking directly to Paul, he means that Paul himself should be able to see different solutions in the sketch, the drawing is not supposed to be presented to anyone else (such as an external jury, for instance) but instead, serve as a tool for the student to see different options for his project and to experiment with solutions. In this case, sketching becomes a short experiment in which teacher and student actively participate; it is a frame of reference that they share, which provides a basis for their discussion. Albert is demonstrating for Paul how he can work and reflect simultaneously, that is, how he can reflect while designing. This notion is evident in the next segment:

ALBERT

And say that this is round, and say that the flooring here has a little differentiation and everything is here⁸⁹. That’s why it is good to always keep on drawing these things in this initial stage to understand the distribution... and here it’s perfect, these are the right kind of sketches, to register ideas, layout drawings contain all the ideas.

This segment seems to conclude several points that the teacher has been raising. We underlined the verb say because it stroke us as an interesting word choice from Albert; for the teacher, sketches are not passive

⁸⁹ “Everything is here” illustrates the notion that the drawing contains all the necessary explanations.

representations of ideas, but rather the designer can have a dialogue with a sketch. The teacher is again using his drawings as an example, it is clear that Albert wants to make this point clear: using a particular type of drawing is an important tool for the student's design process. When he says "and everything is here" Albert is expressing that these type of sketches (the teacher refers to them as "layout drawings") are particularly useful to explore partial solutions and to create quick records of ideas. In his own words "these are the right kind of sketches, to register ideas, layout drawings contain all the ideas."

4. Considering cleaning

In the next segment, we observe Paul driving the conversation again. During their meeting, Albert and Paul alternate conduction of the dialogue. During his turns to steer the conversation, we watched the student continually surveying his sketches, turning his attention here and there, looking for his ideas, notes, and questions.



Figure 21: The student in control of the conversation.

PAUL

Considering cleaning, then I started to think about, basically, automatic-cleaning. That is, here you have... ah, right, floor cleaning and seats it's here... more or less... windows, and then support handles... that is, I've seen Italians, pick a handkerchief to hold the handle on the bus, or some other public transport, in this case it was a train. But I thought "okay, so, maybe it's the issue of the A-flew..." these are cultural issues... maybe to us... but okay.

The above segment illustrates the difference between Paul and Albert's discourse. Where the teacher is authoritative, assured, and eloquent the student is tentative, unsure, and less fluid in his discourse. Also, Paul's approach is more fragmented, that is, the student seems to focus on a single subject at a time (in this case, cleaning) and has difficulty relating the details to the whole design. This approach leads him to a standstill, to become stuck, he seems to have collected several observations from his field research, but he is having difficulties synthesising these in a design idea.

ALBERT

The question is that that material, that kind of stainless steel, is quite resistant –

PAUL

Mm-hmm.

ALBERT

– but then when you touch it, if there is humidity or condensation and it's greasy and whatever, the feeling is unpleasant right?

PAUL

Yes, exactly.

ALBERT

If you put some other coating there, so that you don't feel this...

PAUL

Maybe it's also connected with the issue of hygiene, right?

ALBERT

Which is fundamental in a public transport.

PAUL

Therefore, right, I began to think about things that would automatically clean... windows... and hand supports and all that...

Paul seems interested in discussing an idea of automatic cleaning, but this segment is abruptly interrupted by the teacher that radically changes the focus of the conversation (below).

5. Scanning the student's sketches

ALBERT

Look Paul, what about this general layout, to make a zoom out.

PAUL

Okay.

Albert is referring to a sketch of Paul “this general layout” to change the course of the conversation. The teacher seems determined to keep a broad perspective of the project instead of concentrating too long on specific aspects, which appears to be the approach of the student. Let us recall that previously, Albert had mentioned the importance of keeping a general idea of proportions without being limited to specific dimensions. It is interesting to note that, in the segment below, Albert places a sketch from the student at the centre of their conversation.

ALBERT

I like what I see here, what were you... proposing here?

PAUL

This, basically came from... from... both the necessity of the driver and the conductor, this was developed more towards the conductor, where here that first layout... appears again, that is, where... if the road is here, then here there would be the less space possible, then the conductor would be able to enter quickly and hold this support here, and then he could circle the whole tram while the tram was moving to check if all the passengers had their tickets validated.

The first thing to notice is that the teacher did not seem interested in the direction the dialogue was heading; as we have seen, Paul spoke at length until he reached a dead end in his reasoning. It is interesting to note that the teacher eventually discloses in Paul’s sketches more than the student was able to express verbally, his interruption is expressed positively “I like what I see *here* (...)”.

The teacher’s insight seems to be rewarding since, for the first time in this conversation, Paul is making connexions between design domains (so far the student insisted on approaching the problem in a fragmented way, addressing each issue separately); here, Paul is considering the driver and the conductor, as well as the context and the way that his proposed layout enables the route of the conductor to be more efficient.

Next, the teacher tries to clarify some issues which are not evident in the student’s sketch, and proposes, again, that if the student had used a complementary cross-section drawing, then his idea would have been more precisely illustrated:

ALBERT

And this support point is upward/on top?

PAUL

It's upward. Exactly. So, okay, maybe I have to make another drawing (laughs).

ALBERT

Yes, yes, I mean no, look, if you just had a section here –

PAUL

Exactly.

ALBERT

– then this would be understandable right? So, it's that thing, I got it now, but what about this here?

Albert proceeds by pointing to another sketch of Paul “what about this here?”, the student appears to be more at ease while describing his ideas as they are laid out on paper than when only speaking.

PAUL

Here, basically, the idea came from having the seats for people with reduced mobility up front.

ALBERT

Mm-hmm.

PAUL

There would be both the usual reserved seats and people who want to seat immediately, because maybe they can't make it to the back with the tram moving.

ALBERT

Okay...

PAUL

So then they would have these handles... these handles above and basically... had... had all along the tram... following this whole front part until these benches. And here again they would have a... standing area.

ALBERT

Okay, erhm...

PAUL

That is, here you would have benches on both sides.

The teacher does not pick up on the student's comments, nor does he respond negatively, he just nods and listens. What follows is another sudden interruption – by the teacher – of the natural flow of the dialogue

for an even more extended overview.

6. The teacher offers an overview

With his interruptions the teacher is, effectively, determining the direction as well as the focus of the dialogue, he is in control and decides when to change course and introduce an issue for discussion or move in a completely different direction. Albert stops and offers an overview, he scans the student's drawings and begins to identify various trends for the project and distinguishing among various ideas.

ALBERT

Yes. Yes, yes, yes. It seems to me, if you will, and from what I've discussed here with you at this moment, here this is a third layout, right? Because it's a bit different, what you do in terms of layout, it's three possibilities and there will be more. Now, at the moment it's not ready yet, and I know it's not supposed to be ready yet, this is just a pointing⁹⁰ sketch but it would be interesting that you Paul would take this and tried to make it with a more or less correct proportion, that is, to understand if, in fact, how many benches can you fit there? –

PAUL

Ah, okay.

Albert identifies three different concepts, or three different directions in the student's project. The teacher also suggests a way to proceed: which is to introduce correct geometric proportions into the sketches (an issue that Albert had already raised before). By stopping suddenly to reflect and try to make a synthesis of the student's project, Albert is demonstrating to Paul the importance of keeping a sense of the whole, that is, a general perspective of the project throughout the process.

The teacher openly evaluates the state of the student's project, offers a synthesis, and proposes the next design moves. He demonstrates how to deal with a large amount of information, how to combine different ideas, and how to alternate between a focus on detail with a sense of the whole. He is showing the student how to design, but incidentally, there was no moment during his demonstration to allow the student to actively participate in the synthesis.

Albert then elaborates on how the student should proceed. He suggests

⁹⁰ Albert uses the term "pointing sketch" in the sense of *thinking sketch*, a drawing which is underdetermined and not meant to be presented to others.

that moving from thinking sketches to sketches with some correct sense of proportion can move the project forward, since the definition of the proportions will result in new constraints. Albert uses one of the student's layouts as an example for his explanation:

ALBERT

– maybe you can fit more. Maybe, and I don't know this by heart, but the total of a tram nowadays, I'm not sure how many seat rows it has, but imagine it's six or seven?

PAUL

No, it's less.

ALBERT

Okay. Let's say it's five, so, they're probably more than you have there. Therefore, it is important to fine-tune this a bit. In a very simplified way, but understanding the proportions without over thinking it in terms of dimensions, but having a general idea... so, ideally, maybe you should print a floor-plan that has the dimensions, actually, you should print: top-view, side-view, and front-view, with the areas for the benches and doors, so that when you sketch you can have a sense of scale okay? And here, think about the driver as well.

The previous transcript is particularly insightful; Albert explains to the student how to proceed: "in a very simplified way, but understanding the proportions without over thinking it regarding dimensions, but having a general idea". Albert advises the student to print several sheets with the orthogonal views and use them as a working tool, as a way to flesh out ideas. All the while, the teacher emphasises the importance of keeping a sense of scale and the whole design. He is not solving the student's layout problems but instead giving Paul an example of how to proceed with his designing. He does not show *what* the student should design but rather *how* he should design.

It is interesting to note that the teacher builds from specific issues of the student's project and blends them with a clarification of how to conduct his design process, effectively combining both dimensions of design language in his talk. The teacher's explanation serves the purpose of making the implicit design process explicit for the student. Albert is providing templates (both for thinking and of acting as a designer) for Paul to use for himself. By supporting his exposition in the student's project, Albert renders his talk less abstract, since his words have a clear referent for the student.

Let us now examine how Paul reacts to Albert's demonstration. In the following segment, Paul turns away from the more general discussion that Albert just introduced, and instead picks up on the teacher mentioning the driver to focus on that specific detail of his tram's layout. As was the case before, Albert follows with verbal queues of understanding such as *mm-hmms* and *okays* but does not engage with what the student is saying:

PAUL

The driver, exactly. That is, erhm, there's the issue, mostly, of visibility.

ALBERT

Mm-hmm

PAUL

That was erhm...

ALBERT

To have a wider visibility.

PAUL

Visibility of the passengers, and visibility of pedestrians.

ALBERT

Okay.

PAUL

And then I thought, I don't know if it makes a lot of sense really to place the... the driver towards the centre... to find a way to... to organise this entrance. Then I began... but I really wasn't happy with this... all this because sometimes I've seen in the tram the driver has to get up to see if he is going to hit the car that is illegally parked to the right...and... there, if for example in a car it makes sense that the driver is placed to the left because it is going to cross with other cars, right?

ALBERT

Mm-hmm.

PAUL

In the tram, maybe it would make more sense... to be on the right? I don't know...

As we have seen before, the student tends to focus on single subjects in a fragmented way, an approach that ultimately leads him to become stuck. The teacher does not develop the themes that the student introduces, as we saw above, Albert follows what the student says without significantly

adding to the conversation.

7. Unravelling the ball of thread

The interaction is coming to its end. Albert will follow with the longest verbalisation of the conversation, in which he makes a summary of the interaction:

ALBERT

Then, Paul, maybe it's a bit what we've been talking about here, and to wrap-up, you have three different layouts, and maybe the driver, in one of those layouts, can be in a certain place. And maybe if you start to think about each one of those, for each one one thing or the other makes more sense. And this way you organize your information and begin, calmly, to aggregate ideas for concepts that are different and allow for different ideas. So, I would suggest that. I think you're going really well. Think about clustering these things and to do that the tool is clearly this: generic views, even though this is quite neat [the perspective] but some people can draw like this and others can't. And so, don't think you have to do a gorgeous perspective, no, for now, it's all about space organization. So I think this is interesting, let's try and see if it makes more sense in one concept or the other. It seems to me that it was interesting that you started in a random place and then you kept unravelling the ball of thread that lead you to all kinds of things. Don't forget, every now and then, to look at the overall requirements and see if the concept still includes everything, right?

The teacher begins by elaborating on the synthesis he had done before. Taking into account Paul's sketches, Albert can identify three different concepts; to each of the concepts, Albert suggests that the student should proceed by aggregating the ideas he already has in domain clusters because some of his ideas will make more sense for some concepts but not others.

Albert is reflecting out loud about the project of Paul. He is demonstrating how to think with a broad perspective while keeping a sense of the whole project "and this way you organise your information and begin, calmly, to aggregate ideas for concepts that are different and allow for different ideas." The teacher is showing how to approach the project in this phase where there are many ideas being proposed and explored, how not to

lose control of the information gathered as well as the data generated by the unfolding of the design process itself. The teacher's approach again combines an evaluation of the project with a proposal of design moves.

The teacher's discourse is overall encouraging – “I think you're going really well” – and he reinforces that orthogonal drawings (with correct proportions) are the best tool for this stage of the project “(...) and to do that the tool is clearly this: generic views (...)”, this seems to be a crucial point for the teacher and one he is adamant the student understands by the end of the conversation. Albert distinguishes between different types of drawing, stating that it is more important, during this stage, to use *thinking sketches*, instead of presentation drawings or renderings “even though this is quite neat [the teacher means a student's perspective drawing is neat] but some people can draw like this and others can't. And so, don't think you have to do a gorgeous perspective, no, for now, it's all about space organisation.”

Albert concludes with an explanation of Paul's design process. A very insightful moment when the teacher is reflecting out loud for the student, basically, demonstrating to Paul how to reflect on his designing: “it seems to me that it was interesting that you started in a random place and then you kept unravelling the ball of thread that lead you to all kinds of things. Don't forget, every now and then, to look at the overall requirements and see if the concept still includes everything, right?” Albert uses the *ball of thread* metaphor as an explanation of the student's design process; the teacher is deliberately using an image to express a somewhat abstract idea: the process of designing as something that unfolds, that is ongoing, and which one must pursue.

Curiously, this time Paul did not revert to a focus on specific issues, or isolated questions, instead the student reacts with a reflexion of his own. The student expresses an understanding of at least part of what the teacher tried to convey, namely that where he began his exploration (the topic of people with reduced mobility) was not necessarily where he ended up:

PAUL

Yes, I started with people with reduced mobility and then it was for everyone!

The conversation concludes with the teacher reinforcing that Paul's reflection is a good thing:

ALBERT

But there is no harm in that, you just have to start somewhere. And you arrived at several different concepts, and that's what matters okay?

PAUL

Okay.

Design language summary tables

ALBERT (TEACHER) META-DESIGN DISCOURSE

Transcript	MDD Category	Verb.
<i>Then, and that's why the side-views are so important, and that's why I was insisting on the floor-plan, when you use this view you see that the compartments of the wheels are wasted areas, right? (Rep)</i>	Rep.	6
<i>I'm not worried about dimensions but I am worried in making a proportional drawing (Rep), generically proportional. In order to understand that it turns...</i>	Rep.	12
<i>And so, when you think about this type of strategy you can then understand what you can do inside okay? (Mov)</i>	Mov.	13
<i>Something like this, this is very easy to clean and it is a differentiated flooring that someone can feel, that there is something different, now, with a drawing like this you can immediately see that issue. (Rep)</i>	Rep.	24
<i>And say that this is round, and say that the flooring here has a little differentiation and everything is here (Rep). That's why it is good to always keep on drawing these things in this initial stage to understand the distribution (Mov) ...and here it's perfect, these are the right kind of sketches, to register ideas, layout drawings contain all the ideas (Rep).</i>	Rep. Mov. Rep.	25
<i>Yes. Yes, yes, yes. It seems to me, if you will, and from what I've discussed here with you at this moment, here this is a third layout, right? (Eva) Because it's a bit different, what you do in terms of layout, it's 3 possibilities and there will be more. Now, at the moment it's not yet, and I know it's not supposed to be yet, this is just a pointing sketch (Rep) but it would be interesting that you Paul would take this and tried to make it with a more or less correct proportion, that is, to understand if, in fact, how many benches can you fit there? – (Mov)</i>	Eva. Rep. Mov.	37
<i>Okay. Let's say it's five, so, they're probably more than you have there. Therefore, it is important to fine tune this a bit. (Eva) In a very simplified way, but understanding the proportions without over thinking it in terms of dimensions, but having a general idea (Mov)... so, ideally, maybe you should print a floor-plan that has the dimensions, actually, you should print: top-view, side-view, and front-view, with the areas for the benches and doors, so that when you sketch you can have a sense of scale ok? (Rep) And here, think about the driver as well.</i>	Eva. Mov. Rep.	39

ALBERT (TEACHER) META-DESIGN DISCOURSE

Transcript	MDD	
	Category	Verb.
<p>Then, Paul, maybe it's a bit what we've been talking about here, and to wrap-up, you have 3 different layouts, and maybe the driver, in one of those layouts, can be in a certain place. And maybe if you start to think about each one of those, for each one one thing or the other makes more sense (Eva). And this way you organize your information and begin, calmly, to aggregate ideas for concepts that are different and allow for different ideas. (Mov) So, I would suggest that. I think you're going really well. Think about clustering these things (Mov) and to do that the tool is clearly this: generic views, even though this is quite neat [the perspective] but some people can draw like this and others can't. (Rep) And so, don't think you have to do a gorgeous perspective, no, for now, it's all about space organization. So I think this is interesting, let's try and see if it makes more sense in one concept or the other (Eva). It seems to me that it was interesting that you started in a random place and then you kept unravelling the ball of thread that lead you to all kinds of things (Mov). Don't forget, every now and then, to look at the overall requirements and see if the concept still includes everything, right? (Ref)</p>	Eva. Mov. Rep. Eva. Mov. Ref.	42
<p>But there is no harm in that, you just have to start somewhere (Mov). And you arrived at several different concepts and that's what matters okay?(Eva)</p>	Mov. Eva.	43

Legend:
Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;
Lea: Design learning

Table 37: Albert's meta-design discourse

ALBERT (TEACHER) DESIGN GRAMMAR

Design Grammar Category	Transcript example	Count
Configuration	<i>If we change this architecture we might get there</i> [9]	12
Representation	<i>Those large sheets are great.</i> [2]	11
Usability	<i>And the accessibility to those parts.</i> [16]	6
Materials	<i>The question is that that material, that kind of inox, is quite resistant</i> [26]	6
Composition	<i>In a very simplified way, but understanding the proportions without over thinking it in terms of dimensions, but having a general idea</i> [39]	5
Context of use	<i>and go there again and observe it again and see where there are certain issues... why is the flooring so high?</i> [8]	5
Operation	<i>and the issue of the way the wheels are set in order for it to turn with a short radius</i> [10]	4
Part of artefact	<i>This issue of having big stairs, maybe it's... important to realise why... if you change the electrical system maybe we can have smaller engines and then the access to it is somewhere else</i> [13]	4
Precedent	<i>In buses, the wheels are further apart and that's why they don't fit in certain areas.</i> [12]	4
Structure	<i>The seats could be attached to the side.</i> [20]	2

ALBERT (TEACHER) DESIGN GRAMMAR

Fruition	<i>if there is humidity or condensation and it's greasy and whatever, the feeling is unpleasant right? [27]</i>	1
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Table 38: Albert's summary of design grammar use; verbalisation number between brackets.

PAUL (STUDENT) META-DESIGN DISCOURSE

Transcript	MDD Category	Verb.
Yes, I started with people with reduced mobility and then it was for everyone! (Ref.)	Ref.	43

Legend:

Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;

Lea: Design learning

Table 39: Paul's meta-design discourse

PAUL (STUDENT) DESIGN GRAMMAR

Design Grammar Category	Transcript example	Count
Usability	<i>Here, basically, the idea came from having the seats for people with reduced mobility up front [32]</i>	8
Context of use	<i>Okay but then there is the issue of steep streets... which really [8]</i>	8
Part of artefact	<i>right, of course, maybe the electrical parts and the engine must be accessible [3]</i>	5
Operation	<i>Which was the maintenance of... mechanical maintenance, as it were, replacement of parts and [14]</i>	4
Materials	<i>of a textured flooring, if it would be easy to clean or if I would have to compromise. [19]</i>	3
Configuration	<i>In the tram, maybe it would make more sense... to be on the right? [42]</i>	3
User requirements	<i>and then it also has to do with the issue of the blind [19]</i>	2
Representation	<i>So, okay, maybe I have to make another drawing [30]</i>	2
Type of artefact	<i>Right, and that does not happen with the tram.[11]</i>	1

Table 40: Paul's summary of design grammar use; verbalisation number between brackets.

ALBERT & PAUL DESIGN GRAMMAR COMPARISON			
Domain	Sub-domain	Count	
		<i>Albert</i>	<i>Paul</i>
Form	Basic geometry	-	-
	Attributes	-	-
	Composition	5	-
Function	Purpose	-	-
	Usability	6	8
	Fruition	1	-
Materialisation	Materials	6	3
	Structure	2	-
	Operation	4	4
	Configuration	12	3
	System	-	-
Human Factors	Ergonomics	-	-
	User requirements	-	2
	Cost	-	-
	Sustainability	-	-
Communication	Connotation	-	-
	Denotation	-	-
Representation		11	2
Program		-	-
Context of use		5	8
Artefact	Type	-	1
	Part	4	5
Precedent		4	-
Total		60	36

Table 41: Design grammar comparison

5.1.5 Discussion

In the discussion section of the two previous case studies, we sought to relate the results of our observations to other published studies that were found during the review of the literature. For the discussion of this case study, we will slightly alter our approach. We will compare the findings of this study with the previous case studies to expand on what we found before. In this way, we aim to establish connections and contrasts between both Albert & Paul and Robert & Patti's design conversations

with the findings from the previous cases. The approach aims to deepen our findings, to note if there are recurrences in different cases and also to identify emerging patterns.

Therefore, as the case studies unfold, we will use the discussion section to compare the results with each discussion building on the previous one, to gradually develop a synthesis.

Verbal output and general dynamics

The interaction between Albert and Paul was extended and contains several notable episodes. Before discussing the main findings, we will address some of the data in the verbal output table: we gather that the teacher spoke twice as many words (1405 to the student's 712) and had much longer verbalisations (32,7 words per verbalisation to the student's 16).

These results confirm the trend of the teacher talking more and longer than the students. This result is not surprising, although considering that this case involves a graduate student, one might expect an approximation of these numbers to an equal outcome. And yet, more prolonged interaction with a graduate student resulted in an even more clear command of the conversation by the teacher.

We have previously seen that during a design conversation, the teacher has several roles to act. The teacher must try to get information from the student about his design process, ideas, doubts, and so on; however, it is beginning to be clear that students have a low propensity to verbally discuss their processes (a constant in all cases so far). Thus, perhaps driven by a need to understand the students' process, teachers end up not only talking about their own design process but also explaining the students' process to themselves.

An alternative explanation concerns the complexity of the project briefing; in the previous cases, the briefings were not a simulation of a real design project anchored in a specific context. On the contrary, in this case, the project deals with various complexities included in the design of a public transport system. These complexities were absent from previous cases. It is not surprising then that the teacher feels the need to explain more and for a more extended period.

Another difference we noted in the introduction section of this study, was the use of a suggested design methodology. The suggested methodology could be described as a generic sequential description of how a design project could unfold, in other words, it was more a schedule for overall project development than a tool to manage the design process. In that sense, it was clear that Paul benefited from having an organised work

schedule with defined timelines and deliverables; the student arrived at the meeting with the expected material, which contributed to a productive conversation with the teacher. On the other hand, the student seemed to struggle with integrating the information he had gathered during research into coherent design concepts. It is clear that it is in the space between design phases (in this case between research and concept development) that cycles of analysis and synthesis are particularly useful. Perhaps the student could have benefited from knowing more detailed models of the design process or specific design methods to deal with that issue, but it is entirely possible that the studio teachers or teachers from other courses may have provided this information to the students at some point during the course. However, we have no way to confirm this from the information we gathered for this study.

Also regarding the general dynamics of the conversation, it is interesting to note that Albert was the teacher who demonstrated – through drawing – the most so far, that is, Albert often sketched to explain a point of view or idea or to illustrate a particular problem or partial solution. Despite this propensity for (visual) demonstration rather than (verbal) explanation, the word count table reveals an overwhelming amount of the teacher talking.

Of course, the standout result in all case studies so far was the lack of verbal expression of reflection about the design process on the part of the students (in contrast to the teacher's constant articulation of reflection). This scarcity of meta-design discourse on the part of design students is again confirmed in the results since Paul only once expressed reflection on his design process.

Furthermore, the student does not engage with Albert's reflections, instead, Paul exhibited a type of speech which was similar to that of the students in the previous cases, i.e. some nervousness, little confidence, and practically no reflection on the process.

On the other hand, let us note that the three teachers observed so far exhibited entirely different teaching styles. In this case study, Albert combines a tendency for a practical demonstration with lengthy verbal explanations, a different profile from the two previous teachers (which were both quite reluctant to make practical demonstration through sketches). Thus, the cases hitherto analysed suggest that teaching styles do not appear to influence the students' ability to verbalise reflections about their design process.

That is, talking about the design process during a design conversation does not provoke a reaction in the student to do the same; but focussing less on the process and more on practical issues also does not seem to have an impact on the ability of the student to reflect aloud. Finally, consistent demonstrations through sketching do not appear to influence

the student's ability to do so. So far, the students' reflections occur without a pattern or an identifiable causal link.

At the moment we cannot take these insights further than the formulation of some interrogations. The studies analysed seem to suggest that teacher's demonstrations during a design conversation have little impact on the students' ability to reflect aloud about the ongoing design process. In other words, the design conversation itself, with its natural dynamics, does not drive the students to reflect aloud about their process⁹¹.

In Paul's case, we observe that his reflection occurs at the end of the conversation and after an extensive dissertation by the professor.

Yes, I started with people with reduced mobility and then it was for everyone!

Here Paul reflects aloud on a reformulation of the project, i.e. a framing of the original problem or approach in a new way, a reframing of the current understanding of the project; Paul's statement could also be interpreted as an evaluation of his design process. It is also interesting to mention the similarities with Dylan (from case study 1); notice that, in the case of Dylan, his reflection also occurs towards the end of the conversation. While we recognise that this is a curious coincidence, it is not possible to draw any definite conclusions from it.

Nevertheless, it is intriguing that the end of a design conversation coincides with a (rare) reflection of the student about his design process. On the other hand, if we take the example of Janis from case study 2, we observe that not only was she the student who reflected aloud most until now, but she also had the tendency to reflect during the *introductions* to her work; that is, at the beginning of the conversation with the teacher or when she presented a new idea.

Another particularity of Paul's reflection is that it occurred after the teacher used a metaphor to describe the process design; Albert refers to the unfolding of the design process as the unravelling of a ball of thread:

It seems to me that it was interesting that you started in a random place and then you kept unravelling the ball of thread that lead you to all kinds of things

It is important to state that Albert used the metaphor at the end of a

⁹¹ It could be the case that there is a need to develop specific interventions aimed at encouraging the student to reflect aloud about the design process. Perhaps by doing a series of small project experiments where the student is instructed told to do so? Or slowly introduce the subject into the curriculum? We will expand on these interrogations in the final chapter of this thesis (recommendations).

lengthy verbalisation (217 words)⁹². It is also interesting that in all cases thus far, the teachers' prolonged verbalisations tended to be examples of the teacher trying to make the design process explicit for the student. However, the use of a metaphor was unique to this case and seems to have captured in a lively and lucid way a somewhat abstract idea: which is the idea of the design process as unpredictable and exploratory, a process that leads to an unexpected outcome.

Design students are used to think visually; they use models, sketch, draw, make compilations of images, gather colour palettes, and so on, in short, design students deal with visual matter. Therefore, it is possible that the students' habit of using visual means to think (instead of verbal ones) might explain the difficulty they feel in expressing their process verbally. In this case, Albert illustrate an abstract idea (the design process) with a concrete image (a ball of thread). The metaphor was effective, and Paul seems to have captured the essential idea, internalised it, and related its meaning to his way of working.

Here we are faced with the limitation of dealing with a small sample. We would need to observe the efficacy of metaphor to explain the design process in more cases to reach a stable conclusion. Nevertheless, design students seem to cope well with the use of metaphors in their process (Cila, 2013; Gonçalves, 2016) which adds weight to our observation, and furthermore, it seems to make logical sense that the use of metaphor (and visual analogies in general) would help students understand the design process more clearly.

Design language

Let us now concentrate on how the language of design reveals the student and teacher's design process. The application of the language of design model to analyse the protocols revealed a teacher who alternates the use of design grammar and meta-design discourse. Furthermore, Albert frequently established connections between the various domains of design grammar, that is, he did not refer to aspects of the design in a fragmented way. Also, the teacher naturally intertwined both modes of discourse in his talks. This overall appraisal of the teacher's talk is consistent with what we had seen in teachers of previous cases. But there were some particularities in Albert's performance which are worth expanding.

Regarding the teacher's meta-design discourse it is worth mentioning that Albert insisted on types of drawing and how these influence the

⁹² Keep in mind that the average word per verbalisation of the teacher was 31 and the student 16.

workflow and unfolding of the design project. We observed the teacher relating types of sketches with specific phases of the project, and tried to make this clear to the student during the conversation. For Albert, different drawings should be used in different stages of the design process. The ongoing reflection on the core design activity we labelled as *representation* coincides with the teacher's tendency to draw during the interaction; this suggests that, for Albert, drawing is a significant part of the design process.

The teacher's discourse establishes a clear contrast with the student's speech that surprisingly turns out to be similar to what we had seen with the previous students (undergraduates). Even though Paul's speech is more complex regarding content, that is, Paul addresses more issues than the undergraduate students we observed, it seems to us that this is a consequence of the briefing itself being more complex which influences the student to refer to more aspects of the project. But the increase in project complexity did not drive the student to reflect aloud about his design process. Thus, Paul's discourse turns out to be similar to the previous two students, which is curious in the extent that one would expect to find a difference between a graduate and an undergraduate student's speech regarding meta-design discourse.

An interesting peculiarity in the student's coding result was that the most prominent grammar design categories were *usability* and *context of use*. This finding suggests that Paul tends to focus on the user and the context of use, which implies that the student's design thinking is maturing, after all, the context of use and user are a fundamental concern of the practice of a professional designer.

Drawings

The drawings of the student were always at the centre stage during this design conversation. The teacher often highlighted elements and ideas that he detected in Paul's drawings, in fact, Albert seems to realise that he was getting more from the student's drawings than from the student's words. The teacher often proceeded by pointing to more sketches of Paul "what about this here?"

Furthermore, sketching (by the teacher) was a regular occurrence during the conversation. While the student brought many drawings for the meeting, he did not produce any sketches during the conversation. The teacher, on the other hand, often illustrated his explanations with sketches. The propensity to explain using drawing is a different style of teaching comparing to what we have seen so far. It is therefore relevant to note what happens during the moments of drawing.

What emerged most clearly, as the teacher sketched, was the notion of

the sketch as a laboratory for ideas. Albert uses the sketch as a virtual space shared by both teacher and student; in this virtual setting, it is possible to quickly conduct rehearsals and test ideas. Schön made a similar observation during his studies: “designing can be understood as a kind of experimentation. The designer asks himself, in effect, ‘What if I did this?’ where ‘this’ is a move whose consequences and implications he traces in the virtual world of a drawing or model.” (Schön, 1984, p.132) as did Goldschmidt (2007) “(..) it is necessary for them to arrive at a shared task model, by which we refer mainly to a shared vision of the product that is being designed in the form of a visual representation.” (p.49)

It should be noted that during case study 1 we observed the teacher using a physical model for similar ends. In fact, the teacher insisted that the model should be used as a *sketch-model*, that is, as a tool for thinking and not just as a representation of something else.

The notion of the sketch (or physical model) as a virtual laboratory of ideas and as a shared mental model between teacher and student reinforces the realisation that teacher and student often share moments when they design together. These *designing together moments* seem to be particularly interesting for design education because they are shared, that is, it is not only one of the participants who is testing ideas, but rather both teacher and student working on, seeing, and engaging with the same design situation. Therefore, they both participate in practice, and we have seen that learning-by-doing is one of the underpinnings of design education.

Albert used his sketching to explore the design situation. This exploration is crucial in a design project since it would be impossible to do it using simulations or prototypes. In fact, the ambiguity of the sketch facilitates the exploration of multiple possibilities. A computer assisted design (CAD) model, for instance, could also in principle offer possibilities for exploration, but the use of CAD at an early stage of the project has been shown to be counter-productive; for instance, in a study comparing student use of virtual and physical modelling, Charlesworth (2007) concluded that “[i]t would be prudent to restrict undergraduate access to these technologies in the first year of their studies in order to emphasise the importance of the physical interaction with form” (p.43).

Therefore, it seems clear that sketching has the potential to be a tool to explore possibilities during a design project, and – most relevant for our studies – to elicit *designing together* moments between teacher and student. Additionally, sketching also emphasises the visual rather than the verbal.

Furthermore, as we stated above, Albert insisted that Paul should use a specific type of sketch. Several times we observed the teacher mentioning that at this stage of the project, Paul should use plan and side-view

drawings. These drawings allow the student to have an approximate idea of the proportions of the interior space. Albert reinforced that, at this moment, precision is not a concern, but the proportions must be correctly established.

The teacher often explained that this type of drawing elicits an analytical point of view. Plan views (that provide a top-view perspective of the design) are a useful tool in that they facilitate analysis while also defining the overall layout. Many features of the design can be explored using a top-view, side-view, or cross-section; which leads Albert to state that layout drawings contain all the ideas for the design.

Finally, Albert's insistence on what he calls "layout drawings" is an indicator that the teacher is trying to convey to Paul *how* he should design; namely, by being clear on what kind of drawings he should use. Thus, the teacher does not show *what* the student should design but rather *how* he should design. This observation is relevant because we never observe Albert explicitly indicating a solution to Paul's project, instead, the teacher's emphasis is on teaching *how* he should design.

Design learning

In the previous cases, we identified the category of design learning in the discourse of design teachers (in particular Grace of case study 1). In the present case, Albert does not show the same propensity to be clear about what Paul should be learning.

As we have seen, the teacher's approach is didactic in that it is focused on teaching the student how to design and not what to design (by solving the problem for the student). Furthermore, Albert's style is quite practical, because whenever possible, he tries to demonstrate in practice how to design. Albert's hands-on approach coincided with a less verbally explanatory style (hence, perhaps, the absence of the design learning category of discourse). Thus, while *design learning* is a promising category of teacher discourse, it does not appear to be a common form of speech from design teachers.

5.1.6 Conclusions

Albert & Paul's case study repeated the result that emerged from the previous cases: namely, that there is a marked difference between the teacher's ability to verbally reflect on his process and the (almost total) absence of similar manifestations on the part of the student. Considering that Paul is a graduate student we expected to observe him be more fluent in the use of design language. However, this expectation did not come through.

This case had the particularity of the teacher drawing often during his explanations. Albert's drawings alternated in prominence with the sketches that Paul brought to present during the meeting. It was the first time we observed one of the participants generating visual design representation as the conversation unfolded.

The teacher often examined the student's drawings to uncover the student's design process. From small verbal hints of the student or details present in the drawings, the teacher attempts to infer an overarching process at work in the background, in other words, the teacher often tries to connect the sketches with the student's thinking.

Also, from this study emerged the notion of the sketches (whether drawn during the meeting or produced beforehand) as a laboratory to explore ideas. That is, the sketches (and sketching) can have the role of being a virtual space shared by teacher and student; a space where both can explore ideas, test their feasibility, examine potential solutions, and so on.

Furthermore, the role of the sketches as a virtual laboratory of ideas helps to establish the conditions for teacher and student to have moments when they design together. During these moments, both teacher and student engage with the design situation, which encourages the student to participate more equally in the conversation. Also, when designing together, the conversation leans towards a more formative approach, that is, the teacher engages with the practice of designing alongside the student instead of remaining unobtrusive and critical. Working together with the teacher makes the dialogue more practical and allows the student to have a full experience of the design process.

Finally, we observed that the student often reached discursive dead-ends, that is, moments when he was unable to elaborate on ideas or partial solutions, hesitated, and eventually became silent or was interrupted by the teacher. This was particularly the case when the student guided the dialogue, in these moments the student focussed excessively on details without regarding the overall design. The student tended to pick a subject he was comfortable with, but then could not relate it either to an overarching idea for the project or with other partial solutions. This fragmented approach contrasted with the teacher's talk which continually connected parts of the design and paid equal attention to the parts and the whole.

5.2 Case study 4 – Robert & Patti

“Imagine you’re designing a teapot”

5.2.1 Results

FINDINGS – CASE STUDY REPORT

Verbal output

VERBAL OUTPUT				
Teacher /student	Verbalisations	Words	Mean words/verb.	Word percentage
Robert (t)	43	1474	34,2	71,7%
Patti (s)	44	580	13,1	28,3%

Table 42: Robert and Patti verbal output

Description of events

In this design conversation, the teacher (Robert) sits at the head of the student’s table, while Patti (the student) is sitting at the side of the desk to the left of the teacher. There are two more students next to her. A third student stands between them, a bit further back, and observes the conversation.

The physical proximity between both participants, as well as the students that are observing the conversation, is closer to this interaction than the previous one, which makes the observation more difficult. The observing students do not intervene throughout the conversation but take several notes for themselves.

Patti presented her sketches in A4 and A3 size sheets (smaller mediums than what we saw in the previous interaction). She spread some on the desk, however, the table is cluttered with the student’s belongings and so the space to examine the project is reduced.



Figure 22: The student's desk crammed with smaller sheets and the student's possessions.

1. The teacher has an idea

The conversation begins with Robert pointing to a sketch and mentioning that he had already seen it, a sign that he has been following the student's project carefully, and therefore this design conversation is another moment in a sequence of encounters.

ROBERT

Okay, I have already seen these.

Patti replies by pointing to new sketches on another sheet; the statement is accompanied by a small reflexion on her process thus far:

PATTI

These ones I don't think you've seen... so, I kept making sketches...considering possibilities...

Patti is beginning to reflect on her process “I kept making sketches... considering possibilities...” she pauses and hesitates, and her thinking is completed by the teacher who anticipates what the student is about to say and interrupts:

ROBERT

You were making zoom-ins and outs. I think Albert already insisted a bit on the architecture –

PATTI

On the architecture... (simultaneously)

ROBERT

– and in the issues, above all, of layout. There. And Patti, you already have here, some, some, some drawings of possible architectures is that it?

It is worth noting that Robert applies the same term “architecture” that Albert used to describe the tram’s spatial organisation. Patti completes the teacher’s phrase, and they say the word “architecture” simultaneously, which indicates that the term has often been repeated in the studio.

In this segment, Robert identifies that the student alternated between a broad and a detailed perspective “you were making zoom-ins and outs”. The teacher was able to disclose in her drawings what the student was hesitating to express verbally. In other words, the student’s drawings *said* more about her process than she was able to explain herself. With his words, Robert is showing, by example, how Patti can reflect on her work. Also, the teacher is engaging directly with the student’s project. This is clear in the following segment when the teacher suggests specific solutions for the trams capacity:

ROBERT

And we already realised that in terms of capacity, the current tram is insufficient.

PATTI

It’s insufficient.

ROBERT

So, if the current capacity is insufficient, the first thing that comes to my head is: let’s make it bigger. But if it’s bigger then what happens? It won’t fit in the city curves.

Here we observe Robert working with the student on her project, like a senior designer might do in a professional design studio. The teacher

takes control of the conversation and demonstrates how to advance the project from this point onwards. Robert proposes solutions and examines them almost in the same breath as if he was working on his project. At first, Patti is only listening and not actively participating in the discussion, but in the next segment the student follows the teacher's lead and spontaneously suggests a solution of her own:

PATTI

Right. What if I did a caterpillar?

Teacher and student, at this time, are working directly on the project. The student addresses the issues that the teacher raised (the problem of capacity, the dimension of the tram, and the context of the city) and contributes with a possible solution (a caterpillar).

ROBERT

That could be.

PATTI

Then it works, it has enough angle to curve. And it can be larger.

Patti's last statement reveals she pondered the issue of the angle of the city curves and the problem of insufficient capacity. The student built on what the teacher said and integrated it in a partial solution for the project. Note that the idea of a caterpillar-like structure for the tram emerged from the dialogue with the teacher.

2. Order out of chaos

In the following segment both participants continue to engage with the project. However, the teacher will now become the primary driver of the dialogue. This change is clear in the next segment, where we observe the teacher stopping the direction of the dialogue to make a synthesis of what had been discussed hitherto:

ROBERT

Therefore, one: bigger vehicle. Doesn't work. Two: caterpillar, the caterpillar has an interesting aspect which is, during the day, and you probably reach this conclusion already, in the middle of the day there aren't many passengers. Right?

PATTI

Yes. There's fewer...

Again we see Robert posing questions and providing the answers himself, or including an answer implicitly in the question "and you probably

reach this conclusion already, in the middle of the day there aren't many passengers. Right?". The teacher uses the question and answer format as a device to move towards a conclusion he wants to reach, namely that during the day the tram could circulate with just one carriage.

ROBERT

Which means that during the day it could circulate with just one carriage. If it was an articulated bus it could leave one carriage in the station.

PATTI

If it was easy enough to unattach, and reattach...

ROBERT

And then you can work on modularity, right?

PATTI

Mm-hmm

Patti remains engaged with the unfolding of the interaction, and contributes with partial solutions that spring to her mind "if it was easy enough to disconnect, and reattach...". This signals that the student is involved in the conversation, she is alert, attentive, and offers solutions of her own, the fact that the teacher is driving the interaction and making proposals himself does not inhibit Patti from participating, and the dialogue gains a back and forth dynamic.

Considering this segment more closely we gather that Patti takes a suggestion of the teacher that refers to modularity and relates it with the domains of construction and usability, doing so, the student establishes connections between different design domains. During these exchanges, the dialogue settles on a working conversation in which the project evolves, and teacher and student are partners working together. The discussion continues in this mode of exploration of partial solutions by both participants:

ROBERT

There's another possibility. That doesn't have the same appeal to you, but that might generate a second concept; which is, what is the alternative to the caterpillar?

PATTI

Higher tram frequency?

In the segment above, Robert suggests another possibility, but instead of explicitly stating it, he probes the student with a question (and on this occasion does not provide an answer himself). Patti answers almost

immediately, which suggests that the student is perceptive and alert to the unfolding of the conversation. Even though the dialogue is being led by Robert, he now seems to attempt to make the student get there on her own and keeps the student engaged and alert with a question.

Next, the teacher makes another summary of the student's work and proposes to separate the ideas into two different product concepts:

ROBERT

Exactly! Well, right there it means that you, have you noticed that you have two different concepts? You have one that is modular and therefore is based... notice that... this has a product/service relationship that is quite clear. Either I have a lot of trams circulating and it's a smaller thing; and at the end of the day I'm doubling the route's capacity. This is an option and it can lead you to a product. Right?

The teacher's approach so far could be described as *pause and consider the whole*; again we observe the teacher taking a step back to contemplate an overview of the project so far. While verbalising his thoughts, Robert is demonstrating how to think and work as a designer. Furthermore, he also illustrates how to stop during the design process to reflect on what he is doing. Consider the "have you noticed" or the "notice that" which signal the moments when the teacher is directing the student's attention to whatever aspects he thinks are important to highlight. Therefore, even though the teacher is talking in a stream of conscience (his speech is unprepared by definition, given that it is contingent on the work being shown at the moment), these verbal anchors serve as pointers for the student's attention.

Robert's attention to the whole design and diminishing of the details establishes a temporary order to the unstable design process; this order can then be examined with more clarity by teacher and student. In other words, the teacher creates a synthesis from the scattered bits of information he finds in the student's drawings as well as in her speech. Also, he uses the information that emerges during the conversation itself, in this case, a new idea – the caterpillar – that the teacher isolates as a concept to which other partial solutions and ideas can be applied.

Finally, it is worth noting that the teacher makes several written notes but has, hitherto, not drawn a single sketch or made any annotations or small sketches on top of the student's drawings. So far, Robert's performance is one hundred percent verbal.

3. The teapot

After presenting and elaborating a synthesis of the first ideas, the teacher shifts the focus of the conversation:

ROBERT

And what about the difficulties you noticed during the route?

PATTI

Right, the delivery vans stop in the middle of the road, and then the tram doesn't pass.

ROBERT

And when those vans are stopped, is there space for the tram to go around?

PATTI

No.

ROBERT

Well, if it doesn't, then it's not worth it to change the rails, because it wouldn't fit anyway... well, considering that this is going to limit you, or constrain you, in the sense of being a challenge, because constraints can be great challenges. Considering that this will constrain your solution, then what solutions have you designed or thought about for now?

Robert and Patti discuss a problem the student identified when she investigated the route of the tram, namely that the delivery vans frequently inhibit the tram from proceeding with its course.

The teacher considers what the student says and begins, again, to reflect out loud about the problem and possible solutions for it. This ponderation of problem and solution at the same time is frequently observed in expert designers. The teacher takes the opportunity to explain that, when designing, the limitations can be significant and should be considered as challenges. Contrary to what we have observed in previous segments, this time Robert does not offer a solution but instead asks Patti if she has thought about any solutions herself.

PATTI

(deep breath) I thought mostly about accessibility.

ROBERT

Okay.

PATTI

That issue of it being high, I thought about several things... the issue of it coming down, I thought about having one of those electrical ramps that then pick up the man in the wheelchair and then he goes up and enters.

ROBERT

Mm-hmm.

PATTI

Something like that.

This moment marks a change in the dynamic of the conversation. In the above transcript, it is the student who talks more and longer, Robert replies only with verbal cues of general agreement such as “okay” and “mm-hmm”. The teacher is managing the rhythm and dynamic of the interaction, the conversation does not unfold organically, in fact, we observe the teacher picking the moments in which he is more quiet, in the background, and hands the control of the dialogue to the student. Much like a driving instructor might do to a novice driver, the teacher gives the driving seat to the student and only keeps his hand resting on the wheel and his eyes on the road ahead.

The student immediately sets out in the direction of an issue with which she is more comfortable. She has researched about accessibility and can talk about it. However, she loses momentum, and the conversation becomes slow and directionless. Notice also that, Patti immediately concentrates on a specific issue – accessibility – without relating it with a general idea for her project, or with other design elements. Her approach is fragmented.

ROBERT

Patti, can you explain to me what you mean by “the man in the wheelchair goes up?”

PATTI

(laughs) No, I, I...

ROBERT

He doesn't do that does he?

PATTI

No he doesn't go up, _it_ goes up...

ROBERT

What you're doing here, Patti, is a movement... okay, okay, this is automatic, I got it, I couldn't understand what you meant by “the wheelchair goes up”, it's not

the chair that goes up, it's this. Okay, exactly. Okay, nevertheless, it seems to me that, even though this is determinant, it's still secondary considering the total volume of the thing right?

Robert's reply places the focus again on a general perspective. The teacher often makes connections between the elements of the design, the impact that individual aspects and elements have on other aspects and features; as well as relating the parts to the whole.

Also, when the teacher states "it seems to me that, even though this is determinant, it's still secondary considering the total volume of the thing right?" he is establishing a hierarchy between parts and relating them to the whole; the teacher pauses and reflects on how the process is moving along (is this issue relevant at this moment of the project?) this is a type of thinking that the student has not been able to demonstrate verbally thus far.

Finally, the teacher also emphasises the importance of keeping an overall sense of proportion (volume) of the tram⁹³.

ROBERT

Right? Considering the whole package. I can have this working on a thing with 20 metres, or 3 storeys, or with a metre and a half-length, right? There, so, even before that, how did you think about the size of the thing, in terms of proportion?

PATTI

erhm, first I thought when it comes down...

Robert argues that the mechanism of accessibility for wheelchairs the student is referring to would function independently of the overall proportions of the tram. Therefore that issue is secondary for the determination of an overall design at this stage.

The following segment is one of the highlights of this case study. We will observe how the teacher uses a simple example to show the student how to approach any design project:

ROBERT

Imagine that you're designing a teapot. The first thing you'll think about the teapot, is: how much tea will it hold, right?

⁹³ An idea that Albert also emphasises in the previous design conversation (Albert & Paul).

PATTI

hmm

ROBERT

It's a constraint to think "to design this I will look for inspiration in the Renaissance". Before that you have to think "what's the purpose of this pot?" is it big or small? At the end of the day, that's what I'm asking you: how much tea will this thing hold?



Figure 23: The teacher surveys the student's sketches.

In the above transcript, Robert is showing Patti how to think like a designer, that is, how a designer tackles a situation of the sort she is currently dealing with. The teacher describes a thinking template to approach the initial constraints of a design situation and how these have an impact on the design project. The teacher uses an example (a teapot) which is formally and conceptually far removed from a tram; the question

“what’s the purpose of this pot?” is used to illustrate a general design principle, that is applicable across different design situations. In short, the teacher is making visible a general principle of designing. What’s the purpose of this pot is a phrase that echoes the design axiom *form follows function*; what is the purpose of this artefact? What is its role? Why does it exist?

In this case, considering it is a city tram, the teacher identifies the issue of *capacity* as fundamental, a primordial purpose of the tram is to transport people from A to B, as such, a significant constraint is to know how many people can it transport at any given time. This limitation will determine and influence every other partial solution to each of the other related problems of a public transport system (accessibility, comfort, technology, and so on).

4. This is one idea, what else?

Patti does not visibly react to what the teacher explained, instead, in this segment, the student will begin to explain, with a bit more detail, her preliminary ideas for the project.

PATTI

Yesterday I was thinking about that possibility, which was, keeping with the same language⁹⁴...

ROBERT

The dimensions or the language?

PATTI

The dimensions. There. How could we increase the space? And yet keeping it comfortable for elderly people, for tourists...

ROBERT

You talked with Albert about the several possibilities of concepts right? So, this is one. Closed. There.

Patti highlights a sketch that presents a solution that maintains the currently existing tram dimensions, making only small adjustments to increase passenger comfort. Robert does not reply directly but reassured the student that she could present more than one design concept at this stage.

The teacher states that the drawings they have seen could cluster on a concept and he wants to know of other ideas and other possible concepts, and he says this assertively “so, this is one. Closed. There.”

⁹⁴ The student is using the term ‘language’ in the sense of ‘style’.

PATTI

Yes. Erhm... the first thing was, ultimately, if we take some... seats... the tram now has two, two, two... and a row with two and a row with one. And, in the end, it's six seats here. Ultimately, maybe, if we take these six... it would be worth it to have 50 cm more standing space here, and it would be better, less "sardines in a can".

ROBERT

Mm-hmm. Therefore, and you placed the handles there right?

PATTI

I, I, I have many possibilities. One: from more seats to more standing places.

ROBERT

Mm-hmm.

PATTI

And another issue, since this is a circuit than this tram doesn't have the problem of having to circle in both directions.

ROBERT

Ah, it can move to both sides, right?

PATTI

Right. This part we can't use anymore...

ROBERT

That's good thinking, you take advantage... if the tram only has one course... and there you capitalize on the space indeed. It looks like an option to me, the only thing I'm noticing here, considering what you've done, what is this thing here?

PATTI

Ah, this, this was the tube... so that people could grab.

ROBERT

Ah, okay, okay.

Notice in the segment above that Patti refers to aspects of her design in a fragmented way. Namely, she mentions the distribution of seats and the tram circuit being a one-way route. Robert follows the student's explanation while making short questions and he is overall encouraging concerning solutions that optimise the interior of the tram.

It is interesting to note that when the teacher surrenders the control of the conversation to the student, she centres on specific issues without relating them to the whole. This is clear in the following sequence:

PATTI

And, since the windows are lower, I was thinking, the thing with trams is that you can open the windows and it's all very open. So then, if here the space is for standing, erhm, and there's the possibility of riding standing up next to the window it wouldn't make a lot of sense, it wouldn't be safe... so I thought...

ROBERT

The windows should be the same as...

PATTI

So I thought about closing the window or just open it from the middle upwards...

ROBERT

You can have a flexible window. That is, next to the seats or the standing places the window opens at different heights. That's interesting.

PATTI

Yes, also because one of the things I would like to have is visibility.

ROBERT

Right.

PATTI

So...

ROBERT

But then you have to think about a window that is fit for purpose, when the passenger is standing it doesn't go higher than this. When it's sitting down it won't work. This is one idea. What else?

Robert follows the student's description and suggests changes, but rapidly the conversation reaches a dead-end. Without an overall design idea, the student cannot connect partial solutions to the whole or even to other design elements, which leads the conversation to a standstill. The teacher then emphatically ends this part of the conversation "[t]his is one idea. What else?"

6. Retractable seats

Patti goes on surveying her sketches and highlights ideas; in the next segment, the student describes an idea for retractable seats. The whole sequence that follows is again conducted by the student:

PATTI

Another idea is that I wanted the seats to be retractable... but now that the teacher mentioned that, I was thinking that with the wall here it would hit...

ROBERT

It would be worst right?

PATTI

Right, exactly. Other possibilities... another possibility is that the seats could come from the roof, that is, underneath it could almost be for storage.

ROBERT

I think... I think it's cool... but then the issue is the distance to the ceiling. To support people... then it creates a lever... this... a thing that is fixed to the roof and then with a force applied here... this is a huge force. Naturally it is a nightmare. Any force that you apply here... but what we were talking about before about the retractable seats. Naturally, not against the wall of course, mas for example: the ones that are in a line like this, right? These can be retractable.

PATTI

Yes.

ROBERT

And that space can be used somehow, between the seats to carry more people standing.

PATTI

And will people get up to have more standing places?

ROBERT

Well, there is a possibility which is the driver just goes there and locks it. Again, this is product/service, the driver could push a button and lock it. Done.

PATTI

One way to solve the problem of the seats coming from above would be if there was... if it was supported to the wall here, and then here in such a way that people

could grab it there. And then this could still be a place...
a place for storage...

Here we observe Patti continuing to struggle to connect partial solutions with an idea for the whole design. This time, the student relates her idea of retractable seats with a storage optimisation, but there is no overarching idea providing coherence between these two partial solutions. Furthermore, the retractable seats idea has a structural problem (the lever effect) that is pointed out by Robert. The teacher then suggests a solution that would also allow more standing places.

7. Overview

Robert puts an end to this part of the discussion. Again, it is the teacher who stops the unfolding of the conversation to make a synthesis of what has been discussed:

ROBERT

Look, I think you already have some ideas here. We have flexible windows, retractable seats as well, or not. But let's say, the overall product concept, is more or less the same. It is an improvement right?

PATTI

So far! (laughs) I wanted more...

ROBERT

It is an improvement in which you wanted to keep the language and make some improvements on the inside. It's all fine by me. With the variations we just talked about. This is concept 1. Concept 2?

The teacher presents a reflection that serves as a summary of what has been said. Many of Patti's ideas can be summarised in what Robert calls "concept 1" which he describes as an improvement to the existent tram. The teacher then inquires about a possible "concept 2". From the way he frames the question it is clear the teacher is expecting a general idea for the tram and no further discussions of particular details.

Interestingly, in the next segment, Patti expresses a short and rare reflection about her overall design approach or strategy:

PATTI

Right, that's it... I was... thinking first in all the possibilities and then I would combine them so that I would have several concepts.

Patti describes her process as the generation of partial solutions that are

later combined in an overall product concept which will aggregate them. This is a demonstration of reflection about her process of design. Robert appears to understand what Patti is trying to explain, and clarifies the difficulties she might be experiencing with this approach:

ROBERT

So, you don't have enough information yet to have a second concept, is that it?

PATTI

Right...

ROBERT

Because all of this here is more or less the same, right?

PATTI

Right. I think I'm a bit stuck... to the image of the tram.

In the segment above, Patti expresses her dissatisfaction with being stuck. The student identifies the problem of her design being too similar to a traditional tram. She is reflecting on her project but mostly about the state of her design process (she is stuck).

8. Robert starts designing

It is interesting to observe how Robert reacts to Patti's dissatisfaction with her process:

ROBERT

Right. But it's a possibility. It's connected to the image of the tram but with improvements. This is one is done. With improvements and whatever, I think it's great. I think that working with these things here... this could generate other product concepts, right? It's not just a new concept for an interior. It's a new product concept.

PATTI

Right.

Robert is overall very encouraging and considers Patti's concept one is adequate "this one is done (...) I think it's great". Then the teacher focuses on the drawings that Patti showed and suggests that perhaps there are more ideas to explore, in fact, maybe even a whole new concept: "working with these things here (...) it's a new product concept". Therefore, we again witness Robert trying to extract more from the student's drawings than she presented herself.

ROBERT

If it works, it can lead you to new paths... for example, if you consider the issue of frequency or the issue of the caterpillar, you can even have variable caterpillar modules according to the time of day. Whereas this one that you've been working on is a bit inflexible because it's the same product throughout the day, this one can have different typologies of caterpillar, that is, the caterpillar carriage of the end of the day, or middle of the day. Summer caterpillar carriage. Maybe the basis of the carriage is always the same, right? But it could be built with other stuff attached; imagine that the tram at some time of the day always carries children, and other times it doesn't, you can have the tram going to the station and change carriages to one with smaller seats that can hold a lot more children. For example. But it's a completely different concept. In frequency, in size, in functioning.

The segment above is another main highlight of this conversation: notice how Robert begins by suggesting that exploration of other solutions may lead to new paths, but quickly the teacher becomes enthusiastic with his explanation, and he ends up coming up with a product concept of his own on the spot. Namely, an idea of versatile caterpillars that alternate during the day according to the passenger frequency and also with the seasons.

As we have seen above, the caterpillar initially was Patti's idea. But it was Robert when confronted with Patti's inability to describe another design concept for her tram, that recovered the idea as a possible concept 2. The teacher then gets carried away with the idea, becomes wholly engrossed in the process of explaining it, and ends up describing the concept in detail.

Patti replies enthusiastically to the idea proposed by Robert.

PATTI

Yes, but the caterpillar can have those possibilities... it could even have an elderly people area, another one for tourists...

Robert is visibly enthusiastic about his idea for the tram. Driven by his explanation the teacher continues to develop the concept adding more and more detail:

ROBERT

And maybe it can be developed within this language... and it would be the "Lisbon caterpillars". The Lisbon

caterpillar. This is really cool! To wrap up, I think you have one with several ideas, with the same language, it's your safe proposal, right? And I think you should work on one of these two. And notice that the further upstream you go, that is, the further you work on the usability the more innovative your concept will be. The further you work on the final product the less innovative it is, because it's just working on details.

PATTI

Ah, I get it. Yes.

Robert concludes with a name for the caterpillar concept and he is apparently enthusiastic about it: "this is really cool!". Then, Robert again adopts an overview stance and proposes a new synthesis: "to wrap up" suggesting that there are two concepts Patti can develop further.

The teacher then begins an extended reflection on the overall design process "and notice that (...)" which begins by making a distinction between beginning from abstract starting points "the further upstream you go, that is, the further you work on the usability the more innovative your concept will be(...)" because otherwise "it's just working on details". This is an interesting statement since we observed Patti neglecting to approach the design from a global perspective. The student even suggested that her approach was to develop partial solutions in isolation and only later connecting them to a design concept. The teacher is advising that this will probably not lead to an innovative design.

Robert's explanation extends to the following segment. Similarly to the previous case study, Robert finishes with a long verbalisation (174 words) which could be described as a micro-lecture on the design process:

ROBERT

Right? If you start even before considering the layout, that's where you can make something completely new. If you start saying that "oh, but a tram looks like this, or that". If I would've said "ladies and gentleman, let's design a tram", right? Then you would start with this [points to typical tram]. And this results in a so and so level of innovation. Improvements. But if we begin with the usability, right? You can improve by designing a product that is not merely incremental. It's a lot more. And I think you're still missing, I wouldn't say three if you can make three then fine, but I think you still only have the first one, erhm, we had suggested a group of 3 proposals but, I think you're still in the first one.

I think you should try to extract another one from there. Okay? I've seen you have a lot of side-views, I've noticed they're all very similar, very inspired on the current tram, which isn't bad, but I would like to see something completely different.

In Robert's view, Patti's work is too anchored in the traditional image of a tram, and this focus is preventing the student from developing more original ideas. The teacher again suggests that the student begins by focusing on the issue of "usability" as a direction to explore for her project. In his feedback, Robert combines an assessment of the current state of Patti's project with an analysis of the process that led to it. His advice is for Patti to slightly change her way of designing. Moreover, Robert hints that she has done enough work already to extract another concept for development "I think you should try to extract another one from there". Finally, the teacher mentions (in an encouraging tone) that Patti should develop more concepts for her project since the deliverables require three.

Robert ends the conversation with some uplifting words:

PATTI
Okay. I'll do it now.

ROBERT
It's now?

PATTI
It's now!

ROBERT
Then do it, and keep up the good work.

Summary tables

ROBERT (TEACHER) META-DESIGN DISCOURSE

Transcript	MDD Category	Verb.
<i>You were making zoom-ins and outs.</i>	Mov.	2
<i>Therefore, one: bigger vehicle. Doesn't work. Two: caterpillar, the caterpillar has an interesting aspect which is, during the day, and you probably reach this conclusion already, in the middle of the day there aren't many passengers.</i>	Eva.	7
<i>Exactly! Well, right there it means that you, have you noticed that you have two different concepts?</i>	Eva.	11

ROBERT (TEACHER) META-DESIGN DISCOURSE

Transcript	MDD Category	Verb.
<i>well, considering that this is going to limit you, or constrain you, in the sense of being a challenge, because constraints can be great challenges (Ref) . Considering that this will constrain your solution, then what solutions have you designed or thought about for now (Eva)?</i>	Ref. Eva.	14
<i>Imagine that you're designing a tea pot. The first thing you'll think, about the tea pot, is: how much tea will it hold, right?</i>	Ref.	20
<i>It's a constraint to think "to design this I will look for inspiration in the Renaissance". Before that you have to think "what's the purpose of this pot?" (Ref) is it big or small? At the end of the day, that's what I'm asking you: how much tea will this thing hold? (Mov)</i>	Ref. Mov.	21
<i>Look, I think you already have some ideas here. We have flexible windows, retractable seats as well, or not. But let's say, the overall product concept, is more or less the same. It is an improvement right?</i>	Eva.	36
<i>So, you don't have enough information yet to have a second concept, is that it?</i>	Eva.	38
<i>Right. But it's a possibility. It's connected to the image of the tram but with improvements. This is one is done (Eva). With improvements and whatever, I think it's great. I think that working with these things here... this could generate other product concepts, right? (Mov) It's not just a new concept for an interior. It's a new product concept (Ref).</i>	Eva. Mov. Ref.	40
<i>If it works, it can lead you to new paths (Mov) (...) imagine that the tram at some time of the day always carries children, and other times it doesn't, you can have the tram going to the station and change carriages to one with smaller seats that can hold a lot more children (Ref).</i>	Mov. Ref.	41
<i>To wrap up, I think you have one with several ideas, with the same language, it's your safe proposal, right? (2) And I think you should work on one of these two. And notice that the further upstream you go, that is, the further you work on the usability the more innovative your concept will be. (Moving) The further you work on the final product the less innovative it is, because it's just working on details.</i>	Eva. Mov.	42
<i>Right? If you start even before considering the layout, that's where you can make something completely new. (Mov) If you start saying that "oh, but a tram looks like this, or that". If I would've said "ladies and gentleman, let's design a tram", right? Then you would start with this [points to picture of a typical tram]. And this results in a so and so level of innovation. Improvements. But if we begin from the usability, right? (Mov) You can improve by designing a product that is not merely incremental. It's a lot more. And I think you're still missing, I wouldn't say 3, if you can make 3 then fine, but I think you still only have the first one, eh, we had suggested a group of 3 proposal but, I think you're still in the first one (Eva).</i>	Mov. Mov. Eva.	43

Legend:
Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;
Lea: Design learning

Table 43: Robert's meta-design discourse

ROBERT (TEACHER) DESIGN GRAMMAR

Design Grammar Category	Transcript example	Count
Configuration	<i>Therefore, one: bigger vehicle. Doesn't work. [7]</i>	9
Context of use	<i>But if it's bigger then what happens? It won't fit in the city curves. [5]</i>	9
Type of artefact	<i>Two: caterpillar, the caterpillar has an interesting aspect [7]</i>	7
Usability	<i>And we already realised that in terms of capacity, the current tram is insufficient [4]</i>	6
Operation	<i>okay, okay, this is automatic, I got it [18]</i>	5
Structure	<i>a thing that is fixed to the roof and then with a force applied here... this is a huge force [33]</i>	4
Part of artefact	<i>But then you have to think about a window that is fit for purpose [31]</i>	4
Composition	<i>There, so, even before that, how did you think about the size of the thing, in terms of proportion? [19]</i>	1
Representation	<i>you already have here, some, some, some drawings of possible architectures is that it? [3]</i>	1
Connotation	<i>and it would be the "Lisbon caterpillars". The Lisbon caterpillar. This is really cool! [42]</i>	1

Table 44: Robert's summary of design grammar use; verbalisation number between brackets.

PATTI (STUDENT) META-DESIGN DISCOURSE

Transcript	MDD Category	Verb.
<i>These ones I don't think you've seen... so, I kept making sketches...considering possibilities...</i>	Rep.	2
<i>Right, that's it... I was... thinking first in all the possibilities and then I would combine them so that I would have several concepts.</i>	Eva.	37
<i>Right. I think I'm a bit stuck... to the image of the tram.</i>	Eva.	39

Legend:
Ref: reformulating; **Rep:** representing; **Mov:** moving; **Eva:** evaluating; **Man:** managing;
Lea: Design learning

Table 45: Patti's meta-design discourse

PATTI (STUDENT) DESIGN GRAMMAR		
Design Grammar Category	Transcript example	Count
Usability	<i>I thought mostly about accessibility. [13]</i>	11
Configuration	<i>And it can be larger. [7]</i>	7
Part of artefact	<i>I have many possibilities. One: from more seats to more standing places. [23]</i>	6
Context of use	<i>Right, the delivery vans stop in the middle of the road, and then the tram doesn't pass. [11]</i>	5
Operation	<i>If it was easy enough to disconnect, and reattach [9]</i>	4
Structure	<i>if it was supported to the wall here, and then here in such a way that people could grab it there [35]</i>	3
Purpose	<i>underneath it could almost be for storage [32]</i>	2
Type of artefact	<i>Yes, but the caterpillar can have those possibilities [41]</i>	2
Ergonomics	<i>if here the space is for standing, erhm, and there's the possibility of riding standing up next to the window it wouldn't make a lot of sense, it wouldn't be safe [27]</i>	1

Table 46: Patti's summary of design grammar use; verbalisation number between brackets.

ROBERT & PATTI DESIGN GRAMMAR COMPARISON			
Domain	Sub-domain	Count	
		<i>Robert</i>	<i>Patti</i>
Form	Basic geometry	-	-
	Attributes	-	-
	Composition	1	-
Function	Purpose	-	2
	Usability	6	11
	Fruition	-	-
	Materials	-	-
	Structure	4	3
Materialisation	Operation	5	4
	Configuration	9	7
	System	-	-
Human Factors	Ergonomics	-	1
	User requirements	-	-
	Cost	-	-
	Sustainability	-	-

ROBERT & PATTI DESIGN GRAMMAR COMPARISON			
Domain	Sub-domain	Count	
		<i>Robert</i>	<i>Patti</i>
Communication	Connotation	1	-
	Denotation	-	-
Representation		1	-
Program		-	-
Context of use		9	5
Artefact	Type	7	2
	Part	4	6
Precedent		-	-
Total		47	41

Table 47: Design grammar comparison

5.2.2 Discussion

Verbal output

Let us begin this discussion with a consideration of the verbal output results. The results are similar for both cases.

VERBAL OUTPUT				
Teacher /student	Verbalisations	Words	Mean words/verb.	Word percentage
Robert (t)	43	1474	34,2	71,7%
Patti (s)	44	580	13,1	28,3%

Table 46: Robert and Patti verbal output

VERBAL OUTPUT				
Teacher /student	Verbalisations	Words	Mean words/verb.	Word percentage
Albert (t)	43	1405	32,7	66,3%
Paul (s)	44	712	16,1	33,7%

Table 48: Albert and Paul verbal output

Again we observe that the teacher speaks more than the student and uses longer sentences too. This is a pattern that emerges from the many cases we have seen so far. Regardless if the students are undergraduate or graduate students, the teacher is inclined to master the conversation. To

this difference of quantitative nature is added our qualitative discourse analysis that has hitherto also revealed substantial differences between teachers and students.

What these last two cases suggest is that the students' evolutionary curve, regarding mastering design language, is slow. At what point do the discourse differences between teacher and student begin to blur? We expected that a graduate student's fluency in design language would be different from that of an undergraduate, but that was not the case⁹⁵.

Of course, our discussion reaches here a limitation because we must keep in mind that we are comparing different courses with different students and teachers, and with a small number of participants. In this way, we can only infer questions and raise lines of inquiry for future research. But be that as it may, the pattern is identified, and it is an appropriate direction for future research.

General dynamics of the conversation

The review took place during the same moment of project development as the previous case-study; according to the suggested methodology, this corresponded to a concept development stage in the design process. Similarly to the case of Albert & Paul, we noticed Patti reached the review having finished her research and with the expected deliverables in the form of early concept sketches, which is a testament to the students adopting the development stages suggested by the teachers. However, like Paul, she also struggled to connect her research with overarching design ideas for her project; in the case of Patti, the struggle was even more evident in that the teacher recognised she did not have enough for more than one design concept at that stage. Therefore, the suggested methodology seems to have helped both students organise their work, but they still required the one-on-one meetings with the teachers to take the decisive steps to progress through project stages.

Even though the teachers shared teaching duties in the studio, it is interesting to note that Robert is a different teacher from Albert. To begin with, he does not draw during the conversation⁹⁶. Robert is interventional and does not exclude himself from participating in the project, but he does so through speaking. We often observed the teacher proposing solutions, and repeatedly putting together a synthesis of design ideas. One of his usual procedures was the question and answer format, but

⁹⁵ Note that there might be other differences between undergraduates and graduates that are not related to fluency in design language.

⁹⁶ It should be noted that while the teacher did not sketch during the conversation, Patti's drawings were always at the forefront as the visual design representations mediating the dialogue.

curiously, it was often the teacher that provided most of the answers, as if he was speaking in a stream of conscience.

A definite template of Robert's teaching style was to stop the dialogue and propose a summary. More than once, we watched Robert summarise the main ideas of the student's project, that is, we observed the teacher taking a step back to consider and provide an overview of the project for Patti.

This pause to consider a synthesis is an example of Robert making an explicit demonstration of knowledge that usually remains implicit at the level of thought. In this case, the teacher thinks aloud, and in doing so reveals to the student his thinking process. Therefore, Robert demonstrates to Patti how he thinks through a design situation. While verbalising his thoughts, the teacher provides a vivid example of how to think and work like a designer. Furthermore, he also demonstrates how to stop during the design process to reflect on what he is doing.

Micro-lectures and use of metaphors

All teachers have revealed a tendency to conduct improvised short lectures on the design process. Robert was no exception, and we witnessed it happen during his conversation with Patti. These moments correspond to uninterrupted and unusually long verbalisations, where the teacher explains some aspect of the process of design. During these explanations, the students remain silent, so the dialogue turns into a monologue (hence the term: micro-lecture).

Of these monologues, we would like to highlight the moment when Robert used a metaphor to explain the design process. Robert applies a metaphor (the teapot) that is entirely different from a tram; the teacher uses the scenario "imagine you're designing a teapot" to illustrate a general design principle, that can be applied to different design situations. In short, the teacher uses a metaphor to illustrate a general principle of designing.

Robert uses the teapot metaphor to explain to the student how to approach the initial constraints of a design project. The teacher proposes that Patti should start from this premise ("how much tea will this thing hold?") and then elaborate on the impact that this constraint have on the development of the project. Considering the project concerns the design of a city tram, Robert establishes that the capacity of the tram is fundamental and therefore a suitable starting point; determining the tram's capacity will influence every other partial solution that is involved in the design of a public transport system.

From the previous case, we had already observed Albert using a metaphor to explain an aspect of the design process. Albert used the unravelling of a ball of thread to describe how it is sometimes necessary to chose a

starting point, almost at random, because the design process will naturally unravel from there. Robert's metaphor, on the other hand, also deals with starting points but proposes that the starting point should be some fundamental feature of the artefact (in the case of the tram, the feature is its capacity) because, according to Robert, more fundamental starting points lead to projects with higher innovation. An idea that becomes clear when, towards the end, the teacher states that "the further upstream you go, that is, the further you work on the usability the more innovative your concept will be. The further you work on the final product the less innovative it is because it's just working on details."

Desk tutorial

In the study's background, we identified that the conversation could initially be classified as a desk-review. Robert and Patti's interaction is semi-private, there is some formality, and an evaluative approach since the teacher is considering the student's deliverables. However, although we can classify the initial conditions of the conversation as a desk-review, the unfolding dynamic of the dialogue naturally overlaps with what we describe as a desk-tutorial.

The dialogue between Robert and Patti settled on a working conversation where teacher and student are partners working together on the project. So, although the meeting is a milestone review, where the student is expected to present her ideas for the project, the dynamics of the conversation soon become that of a desk-tutorial. We have seen how the project evolved during the conversation, with new ideas proposed and examined both by the teacher and the student. This dynamic makes the conversation much more informal and formative than evaluative and formal.

Thus, we verify that a desk-review can become a desk-crit or a desk-tutorial. It is a testament to the typically unstable dynamic of the dialogue between teacher and student in a design studio; a design conversation is an interaction in which both participants are engaged in design practice. It is not surprising then that the dynamics of the dialogue are unpredictable and that the initial premises of the interaction change because the design process is not linear.

So we have a situation in which a semi-formal review turns to a working conversation, similar to so many others that occur in the day to day activity of the design studio.

Generative conversations

Another notion that emerged from the previous studies was that design conversations are generative, that is, during their dialogue, teacher

and student will often propose and develop new ideas for the project. These ideas are not prepared beforehand but instead come into view as the conversation unfolds, the ideas are a result of the teacher-student engagement with the design project.

In the case of Robert & Patti, the student accepts many of the conditions that Robert established during the discussion (for instance, the problem of the tram's capacity, the dimension of the tram, and the context of the city for example), but she considers these premises and uses them to propose a new product-type solution for the tram (the caterpillar). It was interesting to note that Patti examined the issues of the angle of the city curves and the problem of insufficient capacity and proposed a (possible) solution that responds to both constraints.

Engaging with the project during a design conversation is thus productive and generative. Robert moved the dialogue from an evaluative angle (from which it started) to a more formative one and therefore created the conditions for a productive conversation in which Patti felt at ease to reframe the situation, to experiment, and most of all to speculate. Furthermore, as we went through the conversation, we observed teacher and student building on what each said. First, Robert examined the situation and designated some of the critical constraints, Patti then proposed the caterpillar as a solution that appeared to answer those difficulties. Finally, the teacher took the idea of the caterpillar and elaborated on it, effectively establishing the guidelines for a design concept.

This back-and-forth dynamic between teacher and student is not at all the rule, we observed it only occasionally, but when it does settle it is a dynamic that appears to establish the conditions for the student to feel comfortable and experience the unstable nature of the design process. As such, the moments when the teacher and student design together might be a promising educational experience for a design student.

Designing together

Regarding the moments when Robert and Patti were designing together, it was clear that the teacher often tried to work closely with the student on her project. However, while the teacher's engagement with the student's project was evident, the dialogue did not settle on a dynamic of peers; in fact, Robert controlled the conversation and often demonstrated how the project should advance, and proposed and examined solutions himself in close succession.

In this way, Robert faced the interaction with Patti as a senior designer might in a professional design studio, that is, he did not restrain from exploring possibilities and giving his opinion. However, while in a studio

all participants would be professional designers, in the educational design studio the students are still novices. Of course, with Patti being a graduate student, one might expect her performance to approximate a novice professional designer.

However, Patti seldom seemed comfortable with the unpredictability of the conversation. Her discomfort is manifest in a less fluent and somewhat hesitant discourse. On the other hand, the teacher appears to be entirely at ease with the typically unstable dynamics of a design conversation. During the discussion of the project new ideas are considered, the initial premise of the project changed often, both problems and solutions are sometimes discussed in the same sentence, examination of parts and whole are alternated. These characteristics require the participants to be mentally agile to quickly abandon ideas that do not work, propose others, go into the details, and swiftly return to consider the whole. Robert was able to naturally navigate his way through this, while Patti often struggled to keep up.

This situation is evident when Robert, absorbed in the conversation, elaborates on the idea of the caterpillars. It is worth noting that Robert begins by developing the notion that exploration of other solutions may lead to new paths, but quickly the teacher becomes enthusiastic with his explanation, and he ends up coming up with a product concept of his own on the spot. Namely, an idea of versatile caterpillars that alternate during the day according to the passenger frequency and also with the seasons. The segment reveals a teacher engaged with both the project and with his explanations.

Finally, Patti's difficulty in dealing with the uncertainty of the design conversation is also apparent when the student sees herself, momentarily, in control of the dialogue and soon arrives at dead ends from where she can not leave. We observed similar behaviour with Paul in the previous case study. Both students often began descriptions of project details that inevitably resulted in discursive dead ends. Paul and Patti could not make the connection between details and the whole; thus, without an overarching idea to relate to, the students become lost.

It is pertinent to consider how often Robert stopped the conversation to propose a synthesis. In these summaries, the teacher tried to link loose ideas found in Patti's work to form a coherent whole (that the teacher designates with "concept 1", "concept 2"...). We never observed the student taking the initiative to make these summaries herself. In fact, Patti states that she prefers to work with isolated ideas. While it is possible for experienced designers to consider a detail as a starting point for a project, the ability to promptly switch between the whole and the details is an important design skill, which we have observed in all teachers up to now

but rarely in the students.

Design language

Analysis of Robert & Patti's conversation is consistent with the primary pattern that emerged since the first case study: there is a substantial disparity between the meta-design discourse of design teachers and students. Robert, similarly to all the teachers so far, makes many reflections on the design process while we observed Patti reflecting on her process only a couple of times.

Patti's first reflection is, curiously, the first thing she says during the conversation. Patti begins the conversation with a presentation of her sketches accompanied by a small reflection on her process "I kept making sketches... considering possibilities..." as the student hesitates, her thinking is completed by the teacher who anticipates what the student is about to say and interrupts:

You were making zoom ins and outs. I think Albert already insisted a bit on the architecture –

Patti's reflection is hesitant, and it is Robert who completes her thought and summarises what she means. In this segment, Robert identifies that the student alternated between a broad and a detailed perspective "you were making zoom-ins and outs". With his words, Robert is showing, by example, how to reflect on her work.

We noted during the description of events that Robert's comment is an answer to what Patti says, but it is also the result of what the teacher perceives in her drawings. The approach is similar to that of the teacher in the previous case study; that is, Robert, seems to be able to gather more from the drawings than from the verbal explanations of the student, or at least to examine Patti's sketches to complement what she says. Both Albert and Robert revealed the ability to perceive in the student's drawings the design process that originated them. This ability eventually compensates for the difficulty students have in verbally expressing their process.

Menezes & Lawson (2006) have suggested that there is a connection between the way advanced design students describe their drawings and their thinking: "[t]his suggests that the way they describe and the way they use formal and symbolic verbal references might reflect the way they think and the way new thoughts might emerge during the interaction with sketches." (p.583) If there is indeed a connection between verbal expression and the thinking that occurred while drawing (hence, while designing), then Albert and Robert's strategy of interpreting the student's sketches to probe their design process is appropriate and could be a

useful skill for any design teacher.

Patti's two other instances of meta-design discourse occur towards the end of the conversation⁹⁷. Following a moment where the teacher made a synthesis of the student's ideas, Robert asks Patti if she already has a second concept. The student clarifies that her design process involves the generation of partial solutions that will later be aggregated into a general idea for the project, i.e. Patti makes a short evaluation of her process.

Following this reflection, Patti concludes that, at that moment, she is stuck because she is too caught up in the traditional tram image. The attachment to the conventional image of a tram prevents Patti from thinking of alternative solutions to the traditional tram. *Stuckness* was the state in which we first encountered the student (Janis) from case study 2, and like Patti, she was also able to identify her predicament. It seems that students are able, when reaching a dead end (i.e. stuckness [Gonçalves, 2016; Sachs, 1999]) to identify what drove them there, but not how to overcome this difficulty. In both cases, it was the teacher that guided them out of the entanglement by suggesting how the student should proceed.

Often, the way Robert uses to guide Patti out of her dead-ends is by interrupting the flow of the conversation to establish an overview perspective (the moments of synthesis we discussed above).

Design learning

From the case studies 1 and 2 we had observed the teachers describing precisely what the student should be learning from the exercise/design project. We categorised this type of discourse as design learning and tried to gather if they were episodic or a continual part a design teacher's meta-design discourse. The category was absent in the previous case study, and the same is true in this one given that we did not observe the teacher stating what the student should be learning.

Since both case study 3 and 4 concern graduate students perhaps design learning is more often present with undergraduates; this is unsurprising if we consider that students should evolve over time. However, we did not see the students being more fluent in their design language from the first pair of case studies to the last. Definite conclusions are problematic given the limitations of using a case-study methodology, we would require a significant sample to draw definite conclusions; nevertheless, the question arises if instead of being less explicit about what the student should be learning perhaps being more explicit would have a positive

⁹⁷ Although they count as two different verbalisations it is essential to realise that they correspond to a single moment, to a unique reflection. It is important to keep this idea of unity so that we do not lose a complete understanding of the conversation.

effect on the ability of the students to reflect about their design process.

Design grammar

Concerning the use of design grammar, it emerged from the coding that Patti focussed heavily on the category of *usability*; Robert, on the other hand, does not have such a stand out result, the coding result reveals that the teacher spread his focus on several design grammar categories, but at the top is the category of *context of use*.

Also, Robert often intertwined meta-design discourse with design grammar, that is, a consideration of specific aspects of the design with reflections on the design process. This kind of discourse stands in sharp contrast with the student's talk. In fact, Patti tends to focus on disconnected details, not related to each other or the whole design, let alone with her design process.

For instance, when Patti discusses the wheelchair problem (the student wonders how to transport a wheelchair-bound person to the tram), she introduces the theme of accessibility but in fact, just gives one example and does not relate it with an idea for the whole design. The problem is raised almost in abstract, as an issue to consider, it is not rooted in a close consideration of her project. The teacher points out that the question of the working mechanism is not the most important since the mechanism is the same regardless of the design for the tram. In the treatment of this issue (the wheelchair) we get a perfect example of how differently a novice approaches the subject (in isolation, without considering the specific implications for the actual design) comparing to the teacher, who manages to integrate the theme of accessibility with the context of use and materialisation of the artefact.

Other examples of the student taking the same fragmented approach to the design occur when Patti mentions retractable seats and storage optimisation. These solutions do not lead to a direction for the design because they lack an overarching concept. Also when Patti discusses the size and positioning of windows or quantity of seats and standing seats. She seems to focus on secondary (according to Robert) things and not consider the whole, or her partial solutions are seldom related to other aspects of the project. It is often the teacher that, building on what Patti said, makes the connection.

Thus, it is interesting to note that when the teacher surrenders the control of the conversation to the student, she centres on specific issues without relating them to the whole. Without an overall design idea, the student cannot connect partial solutions to the whole or even to other design elements, which leads the conversation to a standstill.

5.2.3 Conclusions

Patti's limited use of meta-design discourse is consistent with the findings of all the previous case studies analysed. The disparity between a design teacher and students is substantial. Although Patti is a graduate student, there was no difference regarding language use to the undergraduates.

Unsurprisingly, considering the cases we have observed so far, the teacher talks longer than the student. The teacher is also visibly more at ease with the uncertainty of the design process. Robert and Patti's design conversation is generative, that means the project changes and new ideas emerge.

Moments when the teacher and student design together elicit a richer project experience for the student. These moments are fostered by direct engagement with the project on the part of the teacher. During the moments when the teacher and student design together the student becomes more at ease and participates more actively in the dialogue.

The student has difficulties in linking between elements of the design. For Patti, partial solutions and problems are mostly considered in isolation. Furthermore, the student also does not connect the parts to a whole, whereas the teacher does this often, and even distinguishes secondary elements from other, more important, aspects of the project. It is clear from this difference in language use that the teacher is in control, self-aware of how the process unfolds, how the decisions might affect parts and the unfolding of the project while the student is not.

The cases studies hitherto analysed suggest that teaching styles do not appear to influence the students' ability to verbalise reflections about their design process. That is, talking about the design process during a design conversation does not provoke a reaction in the student to do the same. On the other hand, focussing less on the process and more on practical issues also does not seem to have an impact on the ability of the student to reflect aloud. In the cases of both Patti and Paul, the introduction of a 'suggested methodology' did not appear to help them manage their design process (albeit being useful in structuring the ongoing project); however, we note that the methodology did not describe design methods in detail.

Finally, consistent demonstrations through sketching also do not appear to influence the student's ability to do so. So far, the students' reflections occur without a pattern or an identifiable causal link. The studies analysed so far seem to suggest that the usual interventions that occur during a design conversation have little impact on the students' ability to reflect aloud about the ongoing design process. In other words, the design conversation itself, with its natural dynamics, does not drive the student

to reflect aloud about her process⁹⁸

98 It could be the case that there is a need to develop specific interventions aimed at developing the student's ability to reflect aloud about the design process. Perhaps by doing a series of small project experiments where the student is encouraged to do so? Or slowly introduce the subject into the curriculum? We will expand on these interrogations in the final chapter of this thesis (recommendations).

Chapter 6

DTRS10 study

Chapter 6 – DTRS 10 Study

The study we present here was the result of our participation in the 10th Design Thinking Research Symposium (DTRS10) that took place in Indianapolis (USA) in October 2014. The analysis of the studies went through several evolutions that are documented in a sequence of publications (Ferreira, Christiaans, & Almendra, 2014, 2015, 2016).

6.1 Background

6.1.1 Introduction

It is important to state how the DTRS study fits in the sequence of the thesis. The study was conducted when the theoretical framework we presented in Chapter 2 was still under development.⁹⁹ As such, the analysis we present here is necessarily different from the analysis of the case studies (presented in Chapters 4 and 5).

Furthermore, the study was conducted in the context of a symposium in which there were several rounds of feedback and interaction between researchers. In our case, the interaction continued since we were invited to publish a book section and journal paper based on the work we developed during the symposium.

The work we did during the symposium and, above all, the successive tiers of feedback we received was fundamental for the maturing of the theoretical framework we presented in chapter 2. As such, although the study has a distinct character from the case studies it adds to the research studies that support this thesis.

The main difference, when compared with the case studies, is that the DTRS study focuses on design grammar solely; also, one of the themes that emerged from the symposium was how to communicate data, results, and analysis in a visual form; this is one of the central issues we explored with this study.

We decided to present the study as it was published in its final form because while when comparing with the case studies there are some differences in some of the terms and also in the methodology, the study is a coherent piece of research in itself.

⁹⁹ For instance, the categories of design grammar used in the DTRS study were different from the final ones we present in chapter 2.

6.1.2 Dataset

For our study, we are interested in teacher-student personal interaction. We used the industrial design junior dataset collected provided by the symposium organisers, which includes the video recordings and transcripts of seven students. The video recordings cover five stages of project development: 1st review, 2nd review, client review, and final review (see table below), of these we have focussed solely on the ones involving teacher-student meetings; this means that the client and final review were not analysed in our study.

DTRS10 DATASET							
	Lynn	Todd	Adam	Alice	Sheryl	Addison	Esther
1 st Review	x	x					
2 nd Review			x	x	x		
Client review	x	x	x	x	x	x	x
Look like review		x			x	x	x
Final review		x	x	x	x	x	x

Table 49: Dataset DTRS10

Therefore the study focussed on nine different interactions spread across three stages of project development: two that took place during the 1st review, three during the 2nd review and four during the look-like review. Unfortunately, the database did not allow following all the students' progress across the different stages (1st, 2nd and look-like review). There are video-recordings of Sheryl and Todd in two different moments, but the majority of data concerns only one conversation with the teacher. Therefore, it is not possible to analyse the evolution of teacher-student interaction between the same teacher and student across all stages of the project.

BRIEFING

The briefing the students were working on read:

“Design Brief on ‘Impromptu Seating’ Project with Office Furniture Company. The seating is to be very casual and provide ‘impromptu’ seating for individuals and small meetings. This new seating concept can also add colour and unique forms to a basically sterile and safe offices cape as typical office colours are typically muted and neutral. Consider your concept pieces as accessories that can bring excitement to the office.”

There were also specific constraints regarding overall dimensions and suggestions concerning possible solutions for material and technology used. The project consisted of individual work and the students had roughly two months to complete it.

6.1.3 Design grammar categories

The framework we present here is founded on the concept of design grammar. Design Grammar (DG) can be understood as a verbal reference to the design elements that constitute the parts of a design. In other words, design grammar refers to the elements used to design, that is, the parts and relationships between them, that are combined in the form (understood as a unified structure of parts) of an artefact.

DESIGN GRAMMAR MODEL

We developed a design grammar model (DGM) to operationalise the concept of DG; the model is not hierarchical, all the elements contribute equally to the whole. In the table below we present the design grammar elements and a short description of each sub-category. Each category is assigned a code (E1, E2...) that was used in the analysis of the transcripts.

DESIGN GRAMMAR CATEGORIES		
Elements	Categories	Description
ELEMENTS OF FORM	E1 Form generators	Point, line and plane. Vertices, edges, surfaces. Volume: positive and negative space.
	E2 Attributes of form	Texture, Colour, Value (light and dark,). Dimension (length, width and depth). Shape (direction, angle, polygons).
ORGANIZATIONAL PRINCIPLES	O1 Composition and visual organization	Balance (symmetrical, asymmetrical). Repetition; harmony; rhythm; contrast; variety.
	O2 Spatial organization	Centralized, linear, radial, clustered, grid.
	O3 Structure of visual relationships	Dominant, subdominant, subordinate. Rectilinear, curvilinear.
COMMUNICATION	C1 Sign	Syntactics, pragmatics, semantics.
	C2 Communication process	Source, message, channel, receiver.
FUNCTION	F1 Purpose	The reason for which it is done. Object or end to be attained.
	F2 Usability	Ease of use; able or fit to be used.
	F3 Fruition	Enjoyment, pleasurable possession.

DESIGN GRAMMAR CATEGORIES		
HUMAN FACTORS	H1 User requirements	Any specific constraint or special user requirement.
	H2 Ergonomics	Anthropometric issues.
	H3 Economic factors	Overall costs (manufacturing and materials.)
MATERIALIZATION	M1 Materials and their characteristics	Manufacturing technologies, tools, and machinery.
	M2 Structure systems	Dynamic; static. Structural loads, forces and equilibrium.
	M3 Configuration geometry	Geometrical optimization: precise dimensions, scale and volumes.

Table 50: Design grammar categories

What follows is a general description of each category.

Elements of Form: includes the most basic and foundational elements of form (point, line, and plane) which are the *form generators*; the combination of these three elements results in the creation of volume (positive and negative space). Elements of form also include the *attributes of form*: dimensions, texture, value (light-dark,) shape (polygons) and colour.

Organizational Principles: concern the aspects of composition, structure and spatial organisation, it is a step beyond the *elements of form* in the sense that these principles address the visual relationships between different parts, between parts and whole, and further explores the transition between two and three dimensions.

Communication: refers to the artefact as part of the artificial world and material culture, it concerns the implications of understanding an object as a sign, that is, the meanings it conveys in a communication process. Design generates material reality, satisfying practical functions and technical performance are only a part of that reality, a design product also deals with connotations.

Function: a crucial aspect of design, function refers to the product's purpose (what needs it is intended to fulfil) usability (the ability to be used, ease of use) and fruition (in the sense of enjoyment, or a pleasurable possession.)

Human Factors: these refer to specific requirements that constrain the artefact. It includes Ergonomics, User Requirements and Economic factors. These factors are entwined with the category of function. The main difference is that functionality deals with more subjective aspects of

the interaction between artefact and user, while human factors are more precise and objective features such as height or age for example.

Materialization: refers to aspects concerning the actual physical materialisation of an object; these include materials and their characteristics (manufacturing technologies, available tools and machinery) structure (dynamic or static, forces and equilibrium, specific structural parts) and configuration (geometric solutions and real dimensions of the object.)

6.2 Methods and procedures

6.2.1 Analysis framework

Our study explores the application of the Design Grammar model as a framework to analyse teacher and student dialogue. For the analysis, we have developed an observational framework which we will now present. The observational framework is divided into three sequential phases:

- Phase A: Identification of events and primary analysis.
- Phase B: Categorization of events;
- Phase C: Analysis.

Events are a short interaction during the dialogue between teacher and student. During the observation of the video-recordings and transcripts, we will search for references to form-giving. These verbal references constitute an event. Identifying the events concludes phase A. It is important to note that, in this study, analysis of non-verbal interactions are problematic: while it is possible to detect moments when the teacher or student are drawing, the content of the drawings are almost impossible to determine from the videos. Therefore, the moments of non-verbal interaction are recognised but not categorised.

During phase B the events are categorised according to the DGM categories, the analysis focusses on both the teacher and the student's input. This information is structured and categorised using an analysis table (fragment of an analysis table below):

Video: first review Todd

Teacher /Student	Evet /Time	Transcript	Notes	DG category
Teacher Gary	8.07.40	<i>Now keep in mind you pull it off, it's gonna – where's it gonna go? Is it gonna go down pretty much, stand on it?</i>		M2

Student Todd	10. 07.43	<i>Go down and then like it would be under your legs, basically. Um, it's kinda a rough idea, but it's kind of out there, you know?</i>	M2 H2 Linked
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Table 51: Example of an analysis table

At this stage (B) the analysis focusses on two questions:

1. Is the subject (teacher or student) expressing information which can be described by a DGM category, and
2. Are the DG elements linked with each other and with the whole?

The combination of both criteria serves to analyse the design grammar fluency of the subject. The criteria for fluency are the frequency and variety of DG references by either teacher or student, and also if these references are linked. While the frequency and variety analysis are straightforward and objective, the evaluation of linking is more subjective. It is not enough that two (or more) elements of DG are mentioned in the same event for it to qualify as linked; there has to exist a meaningful relationship between the elements. Perhaps an example might illustrate the point:

Student Lynn	13. 08.30	<i>And this one is actually just one piece, and you fold it and you create a shape like this. And easy for you to, ah, place it, easy for you to install it.</i>	Points to drawing while talking.	M2 F2 Linked
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Table 51: Linked categorisation.

In the example above, the reference to structural issues (one piece, foldable) is related to ease of use (“easy for you to install it”). On the contrary, a fragmented verbalisation occurs when a participant refers to design elements in an isolated way:

Teacher Gary	5. 09.40	<i>This is gonna be your, your biggest challenge is trying to get your geometry, right</i>	Points to drawing	M3
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Table 52: An isolated categorisation.

After completing the analysis table, and still within phase B, we use the tables to develop a series of diagrams which will sustain the analysis during phase C. These diagrams do not contain extra information, however, the diagrams serve the purpose of displaying the information visually to facilitate an overall perspective of the teacher–student interactions. What follows is a brief explanation of how the diagrams are designed.

6.2.2 Visual analysis

We used the data obtained from the first two phases to create a series of diagrams for our analysis. The diagrams allow for a significant amount of data to be immediately displayed; therefore facilitating the identification of similarities or contrasts and the disclosure of patterns.¹⁰⁰

DIAGRAM DESIGN

The diagram consists of six triangles (composing a hexagon) representing the six areas of the DGM. The black dots indicate the sub-categories of each area. We created a diagram for each event of every interaction for both teacher and students. These diagrams could contain several DG categories or only one isolated element. The dotted lines represent a link between elements. See an example in the figure below.

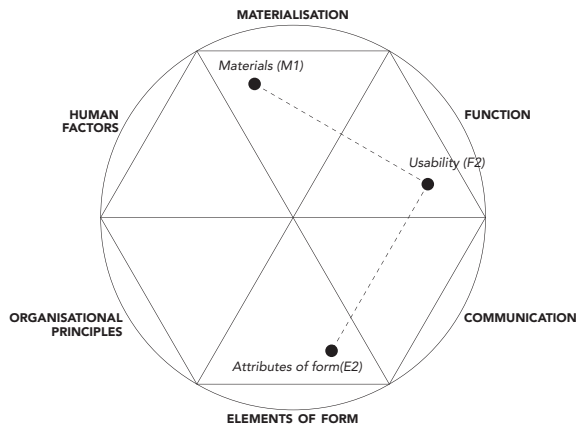


Figure 24: Diagram design

After completing the diagrams for every event, the data is used to create an overall diagram of the complete interaction, which overlays all the single event diagrams. Again, this is done for both teacher and student (figure below). In the overall diagram, the black circles expand in proportion to the number of references made and all the links are displayed as well.

¹⁰⁰ The process of converting large amounts of data into visual communicative mediums can be traced to the beginning of the twentieth century. Otto Neurath (1888–1945) was a pioneer in the creation of pictograms as a way to communicate complex data to the broader public (Neurath, 2010).

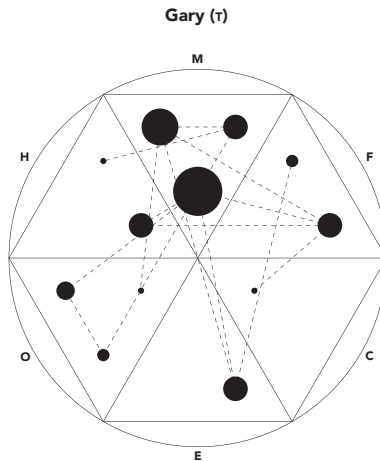


Figure 25: Example of overall diagram

The overall diagrams provide a broad picture of the interaction. The analysis will mostly focus on design grammar fluency: the diagrams show what areas both participants focused on, what areas were absent and the links that occurred. The visual data elicit clear comparisons of the two participants; we will use the visualisations to highlight similarities and differences between teacher and students.

METHODS OVERVIEW

Phase	Objectives	Methods	Outputs
Phase A	Identification of events	1. Observation of video-recordings. 2. Reading the transcripts.	Preliminary analysis table
Phase B	Categorization of events	1. Categorisation of events according to DGM. 2. Statistical analysis of results. 3. Development of interaction diagrams.	Final analysis table Statistical tables Interaction diagrams
Phase C	Analysis	Crossing of outputs resulting from phases A and B.	Qualitative analysis of each interaction. Overall discussion and conclusions

Table 53: Overview of study methods.

6.3 Results

6.3.1 Findings

Lynn and Gary

(1st Review Session)

This session lasted 26m:16s, during which we registered twenty events for Lynn and nineteen for Gary. The figure below presents the overall diagrams of Lynn and Gary. The diagrams overlay all the singular events of both participants. The diagrams are placed side by side, providing a visual summary of the DG content of the interaction. The result is a depiction of the individual perspective of both student and teacher that allows the comparison of the spread and focus of the DG categories.

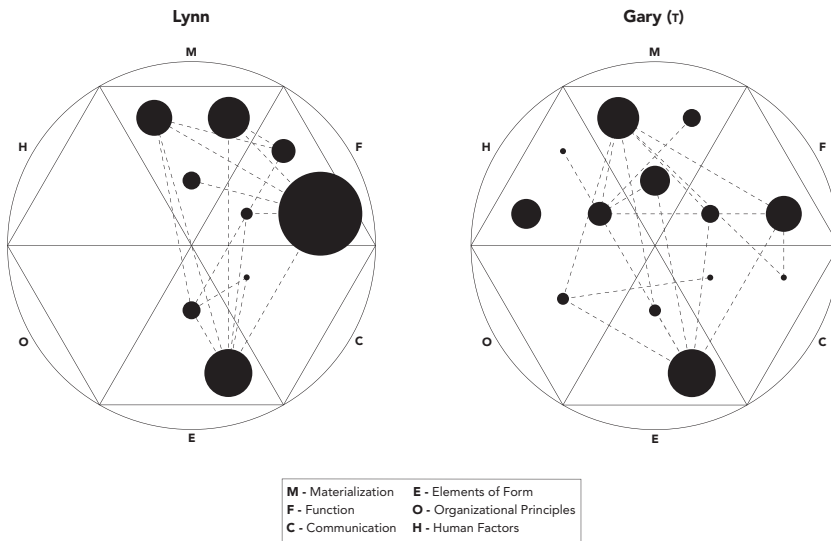


Figure 26: Lynn and Gary overall diagrams.

In the case of Lynn, there is an evident focus on the function (F) categories. Her diagram also reveals that the different elements were linked with each other. On the other hand, the teacher's diagram does not follow Lynn's pattern. Gary's diagram reveals categorisations (namely human factors [H] and organisational principles [O]) that are absent from Lynn's diagram, and there are similarities concerning the elements of form (E) and materialisation (M) categories.

Lynn's focus on function related issues is clear. Her diagram also shows that the different elements were linked with each other. Observing the teacher's diagram, we realise that it displays a balanced distribution of DG elements. It is interesting to note that one of the elements of human factors (namely *economic factors*) is mentioned several times but is never linked with the other elements.

Going back to the transcripts revealed another issue regarding the

dialogue between teacher and student: of Lynn's total of 20 events, 14 occurred in the first 8 minutes of interaction, furthermore, during that 8 minute period, the teacher registers only four events. This suggests that the interaction was not a fluid back-and-forth dialogue between the two; instead, the meeting could be divided in two moments: the first 8 minutes correspond to the bulk of Lynn's interaction and the remaining 12 to Gary's.

Todd and Gary
(1st Review Session)

Todd and Gary's 1st review session lasted 20m:40s. There was a wider disparity between the number of events registered, Gary had 26 and Todd 18. Todd and Gary's overall diagrams revealed an interesting comparison – their patterns are somewhat similar, even though the teacher shows a higher frequency of categorisations. The focus of the interaction appears to be centred on materialisation.

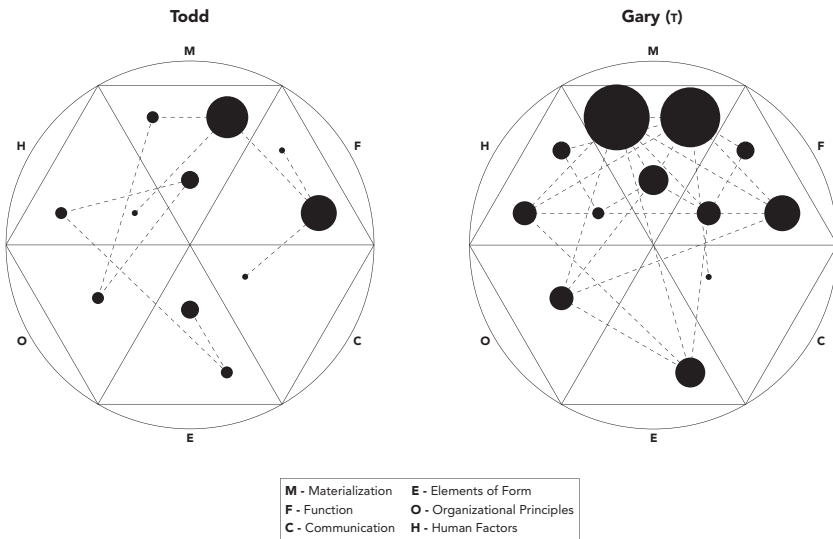


Figure 27: Todd and Gary overall diagrams.

Unlike the case of Lynn, here the diagrams capture similar patterns, both teacher and student concentrated on the same areas of DG, with the only visible difference being the fact that the teacher exhibits a higher amount of categorisations. Furthermore, both diagrams reveal that the different elements were linked.

It is interesting to note that Todd focused on the same elements as the teacher (the percentages are similar except for the elements of form). The significant difference in frequency did not correlate with a difference in variety. In short, Todd had fewer events, but they were focused on the same issues as the teacher. This is clear when observing both diagrams and noticing that while the spread of elements is similar, the frequency is more intense on the teacher's diagram. Todd's diagram also displays his overall articulation of the several elements.

It is interesting to notice that up until the 11-minute mark Todd had registered 16 events and the teacher 17. Considering that the interaction lasted 20.40 minutes, this means that up until that point the dialogue had been almost a perfect back-and-forth balance between the two. There is a part of the interaction which is worth highlighting; at one point during this first half of the conversation, the teacher encourages the student to develop a particular design idea illustrated in his sketches (an idea that the student was not very convinced about pursuing,) this is evident in the following transcript (around the 7.30 minute mark):

TODD

This isn't really, because I don't think they fit on top of each other. I mean they, they could. That might look cool if they were all stacked.

GARY

That creates – to me – I saw that neat little tension. It creates tension, which is kind of neat. (...) You know? And so which offers, and then you could have different materials and colours, but I think there's something unique – about that because it, it is different and it's take – it's geometry, but, you know, you were saying like if you put it in a different context.

TODD

Yeah. So that's the final idea I like, too.

This passage illustrates that (at least during the first half of the interaction) the teacher and student were engaged with the project, discussing ideas as well as making decisions. This is further reinforced since it is possible, while following this passage in the video recording, to identify the sketch they were discussing, and this idea was in fact developed further and became the main concept Todd presented at the end of the project (see figure below).



Figure 28: Left to right (1st review sketch, look-like model, final presentation).

This was a rare moment in which we can detect the impact of the teacher's guidance in the outcome of the student's project. In this case, the teacher's advice influences the whole project, from early ideas to final prototype.

Adam and Gary (2nd review)

The conversation occurs during the 2nd review between Adam and Gary. It lasts 16m:13s and therefore is shorter than both interactions observed in the 1st review. The teacher almost doubles the number of events of Adam (23 – 12).

Concerning the categories of DG, Adam and Gary differ in every category. Adam focused on the elements of form materialisation, and function, whereas Gary had an evident focus on materialization and the remaining categories were more evenly spread.

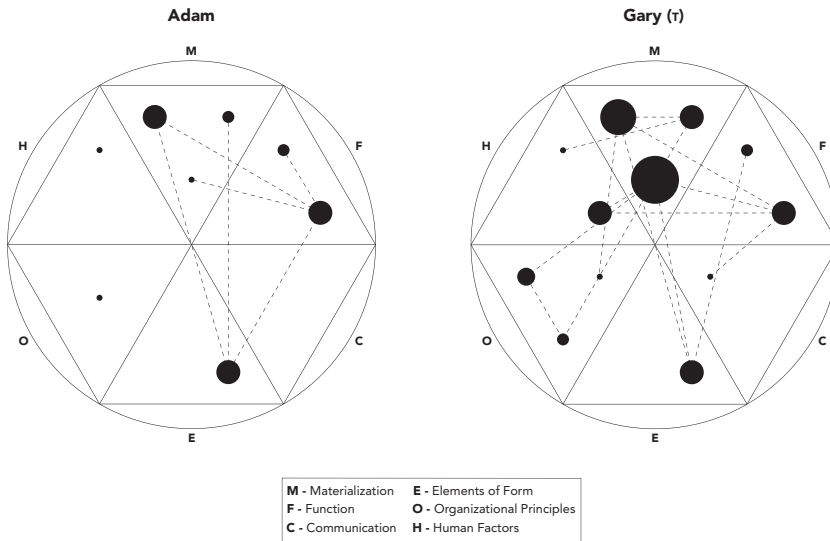


Figure 29: Adam and Gary's overall diagrams.

Adam's events were short but rich with references to DG elements; below we can see a couple of transcripts that illustrate his overall approach.

I know. I'm thinking I want to make the out of fabric so they can play around with it a lot. But right off the bat, I was thinking I'd make it in like dual colors. (Materials [M1] and attributes of form [E2])

Um, this one, going along with stacked idea. Ah, it's a simpler shape, but it's got a little cushion on top, and the roller recessed edge on the bottom so then you can stack them on top of – one another." (Materials [M1], usability [F2], configuration [M3])

The diagrams (figure above) illustrate Adam's focus more clearly as we observe that the links occurred mostly between the materialisation, function and elements of form categories.

This was an engaging interaction. A first look at the data suggests a somewhat different dialogue between teacher and student, especially if we consider how the teacher had a higher frequency of DG categorisations. The participants also differed substantially in the focus of the interaction: Adam focusing on materialisation, function and elements of form, while Gary spread his DG references more widely.

However, a close analysis reveals the opposite. The dialogue had more input from the teacher, but both teacher and student drove it equally (especially in the first ten minutes.) Adam's lower input regarding frequency of events could be explained by his overall dry and direct

approach (using short but meaningful sentences).

During the first ten minutes there were several moments when the participants were finishing each other's sentences, something that can only be fully observed in the video-recordings, but below we present a transcript of one such moment:

GARY

Um, this is, this is better. I mean if you get the same – I would – I would make that between the bases or the, that you – that it – I would probably make 'em the same. Try to come up with the symmetry.

ADAM

Okay. 'Cause I think part of the appeal of this is that it is big – it curves in.

In the above transcript, Gary and Adam say “it curves in” at the same time while making a gesture indicating the curvature. Another highlight occurred around the 3-minute mark; the teacher began to draw extensively in his notepad, something that was seldom observed (at least, with such intensity) during this study. Below we present the transcript of the beginning of the moment (Gary was speaking while drawing).

Who knows? Once – we gotta lay it out to make sure you could you got some comfort there. Maybe what happens is maybe it doesn't split down the centre. Maybe it's more; I guess you mean, something like this – That way you get the base dimension (...) is closer.

For about a minute both participants interacted while the teacher was drawing. The marked difference in focus of DG categories could, perhaps, be interpreted as the teacher taking a complementary approach, similarly to what we observed during Gary and Lynn's interaction.

Alice and Gary
(2nd review)

Alice's interaction lasted 22.00 minutes, which is a number closer to the ones registered during the 1st reviews. This could be explained by the observation that Alice, unlike Adam, was still unsure about what ideas she should develop further. Both Gary and Alice focus heavily on a combination of materialisation and function. Human factors are – as was observed in conversations with other students – absent from Alice's events.

The diagram (figure below) shows that while Alice's focus was placed on materialisation and function, her DG references are linked with each other.

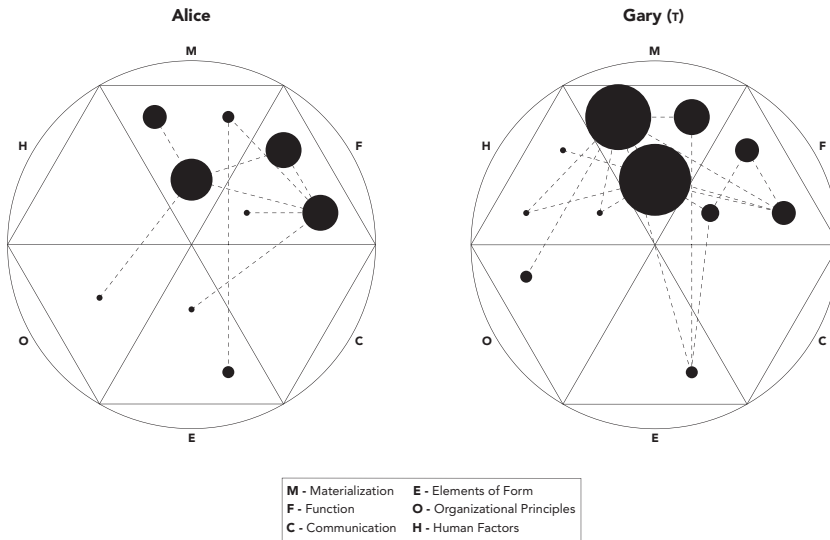


Figure 30: Alice and Gary's overall diagram

Comparing both diagrams we can observe that the teacher tried to include human factors into the interaction, but in general, focused on the same issues as Alice, with an obvious emphasis on materialisation. Where with Adam (interaction 3) and to a lesser extent with Lynn (interaction 1) the teacher's overall diagram illustrated a complementary nature to his approach, here Gary's diagram is a sort of amplified mirror of Alice's.

Sheryl and Gary (2nd review)

The first five minutes of this interaction are missing from the video database. This could explain the short number of events registered for Sheryl. However, it is worth noting we identified thirteen events for the teacher. The recorded interaction is also very short (5:46 minutes).

Sheryl's frequency and variety of DG elements are very low and the focus is almost exclusively placed on materialisation issues.

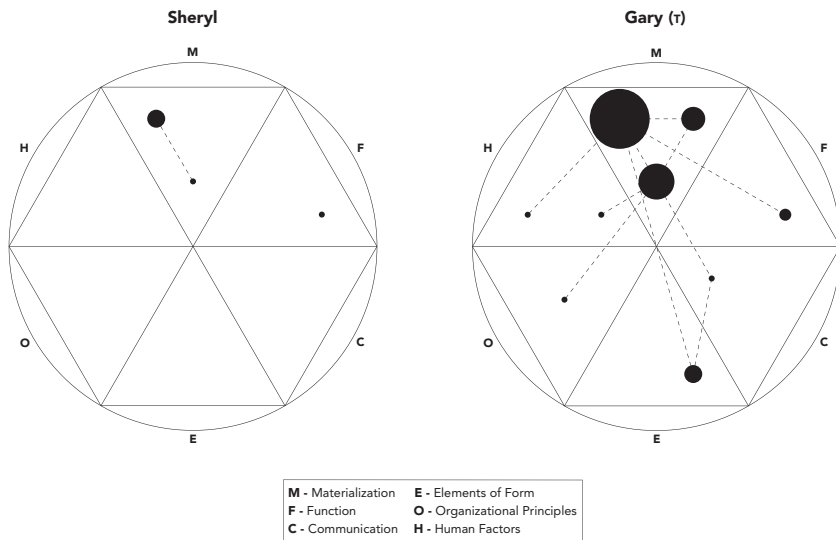


Figure 31: Sheryl and Gary's overall diagrams.

In this case, the diagram illustrates Sheryl's low frequency of DG elements and quite naturally, there are not many links between them. The teacher's diagram does not suggest any particular pattern; it is very similar to the ones we observed in other interactions – overall broader in scope, with more links and variety of DG elements. It is worth noting that the four events we identified for Sheryl occur within the first fifty seconds of interaction, which suggests a unidirectional dialogue driven by the teacher.

We did not find any particularity in the diagrams or in the transcripts, regarding the teacher's overall approach. Unlike Adam's interaction (interaction 3), for instance, where it was clear that Gary had a different performance (more complementary with the student's). This will be discussed further during the discussion section of this study.

Look-like interactions (overview analysis)

The look-like interactions correspond to a stage of the project when the students are working on their models. At this point, crucial decisions regarding the overall direction of their projects have already been made. Therefore, these interactions focus heavily on model-making details (what kind of materials to acquire, how to put them together, and so on) and presentation issues. It is also worth noticing that at this stage the meetings occurred while the students worked with computer-assisted design software. Furthermore, the interactions are much shorter and the

DG content scarce.

The interactions were closer to the 10-minute mark (Addison 11.09; Esther 12.00 and Todd 8.58) except Sheryl's which registered 22.25 minutes. We will look into Sheryl's interaction with more detail below.

Sheryl and Gary
(*Look-like review*)

Sheryl's interaction during the look-like review was not consistent with the overall pattern described above. The analysis of her previous interaction also suggested she had less fluency in DG, as such we decided to look into her look-like interaction in more detail.

The meeting lasted longer (22.25 minutes) than the other three look-like reviews. We identified twelve events for Sheryl and eighteen for Gary. The split widens regarding the categorisations with Gary registering a higher frequency of categorisations. Of the nine interactions observed, this was the only occasion when the number of events equalled the number of categorisations; i.e., in every event, Sheryl referred to only one disconnected element of DG. Below we can see three transcripts that illustrate Sheryl's overall interaction:

SHERYL

I mean I could just make it out of wood, couldn't I? Just like (...) cut a piece of wood?

GARY

And then my other concern – yeah, I wanted it to be symmetrical kind of similar.

SHERYL

Um, and then this would be metal.

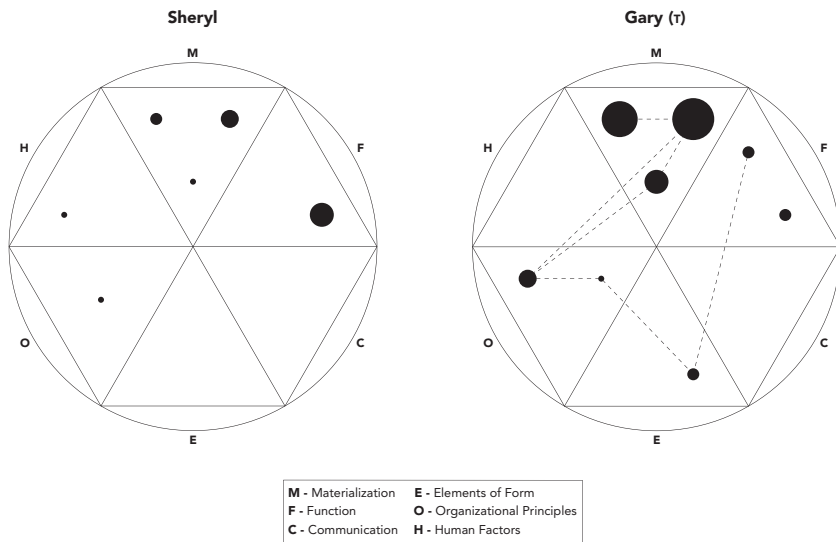


Figure 32: Sheryl and Gary's overall diagrams (look-like review).

Sheryl and Gary's look-like review was a unique case. Sheryl's overall diagram was quite intriguing since it revealed a complete absence of links. Observing Sheryl and Gary's dialogue shows several references to single isolated DG categories (from both teacher as well as student) happening in quick succession.

However, a closer analysis of the sequence revealed an interesting occurrence: Sheryl mentions an issue "and then in the middle, this telescope, so you can raise and lower the table height" that we categorised as *usability*; immediately Gary replies saying "how is that gonna work – just push, pull?" which was labelled as *structure*.

It is clear from the segment above that Gary suggested a structural solution for the usability issue mentioned by Sheryl. Thus, Gary was, in fact, linking both elements with his question. The reverse happened after Gary asked "so where would the lever be?" to which Sheryl replied "Just in here. 'Cause you – I mean to lift it, you have to pull the seats out" in this case Sheryl took a question concerning the structure of her design and linked it with a usability issue. It is interesting to note how the teacher was able to elicit a connection between design elements with two short questions.

The DG elements are referred to separately, that is, disconnected from their effects to the whole, and without linking the various DG elements with each other. It seems relevant to observe that of the eighteen events we identified for the teacher, twelve corresponded to isolated references

of DG elements. The conversation progresses in a balanced dialogue, without either of the participants dominating the interaction. However, we can notice both Sheryl and Gary exhibit the same fragmented approach, that is, they refer to DG elements without linking them with the whole or between the parts.

Thus, both participants seem to mirror each other's approach. This fragmented approach is not representative of the teacher's overall pattern observed during the study. At this point, we would like to raise the hypothesis that the teacher's approach varies according to the student at hand, which is understandable and even expected. However, in this case, the teacher's performance (regarding DG fluency) was lower than before. We have no way to establish, in this study, if this was a deliberate or even strategic approach by the teacher, or if it was a consequence of the natural dynamics the conversation.

Esther and Gary
(*Look-like review*)

We expected to find differences in the look-like review diagrams. As was said before, these sessions were not mediated by sketches but rather by models (physical and computer generated). The look-like reviews were more about practical issues of model making than form-giving. The study's sample does not allow for generalising conclusions, but from the cases we analysed there was a marked difference between the first two sessions (where sketches were central) and the look-like review sessions. Below we present the overall diagrams of Esther and Gary that are an illustrative example of how the look-like reviews unfolded.

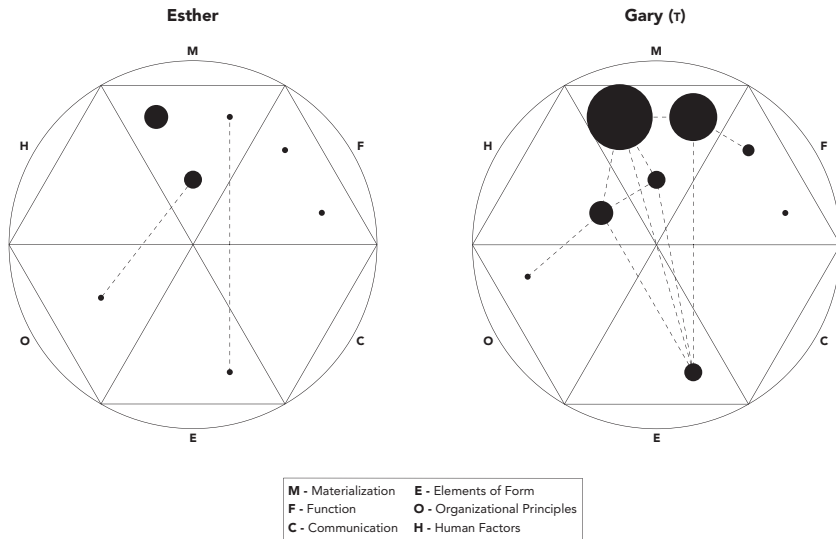


Figure 33: Esther and Gary overall diagrams.

The first thing that stood out was that Esther's diagram revealed fewer connections and aggregate of categorisations when compared with the cases we have seen before. On the contrary, the teacher's diagram, while not displaying a pattern as varied as previously observed, maintains a fair amount of categorisations and connections. This could be indicative, without being conclusive, that the teacher sustains a similar performance, regarding DG, across the different stages of the design process.

6.3.2 Discussion

VISUAL ANALYSIS

This study consisted of an exploration of the DGM as a framework to analyse teacher and student interactions. Past studies suggest that teacher and student interaction within a design studio setting requires specific observational frameworks (Schön 1987); our model, while focussing on the DG categories, has the supplementary benefit of revealing insights regarding the overall dynamics between teacher and students.

The results suggest that there is a common visual language underpinning the teacher and students dialogue since we observed both making use of the same overall DG categories to address form-giving issues. However, what the DGM reveals is that, during a session, teacher and students do not refer to the same categories to the same degree. In fact, the teacher displays a higher variety of categories than the student; and perhaps

more importantly, the teacher consistently exhibits a broader range of connections between categories, elaborating on how different aspects of a design relate with each other and contribute to the structuring of a coherent whole. The students, on the other hand, show a more fragmented approach, focussing on specific areas and drawing fewer links between categories. This is consistent with descriptions of the behavioural differences between expert and novice designers (Cross, 2004).

This insight is not unexpected considering the study sample consisted of second-year students; a sample with a broader range of students might reveal that the diagrams become increasingly similar to the teacher's as the students grow more mature; similar not necessarily in terms of the categories mentioned, but regarding the overall approach and inter-connectedness of the patterns¹⁰¹.

These preliminary insights are encouraging regarding the application of the DGM tool in a practical educational setting. The model could serve as a diagnostic tool that monitors a student's progress over time, as well as a tool for teachers for self-monitoring and reflection on their pedagogical practice. Moreover, future studies could observe the same students across the different stages of the design process. A longitudinal study of this kind would permit the comparison of sequential diagrams, leading to the disclosure of patterns and therefore more generalisable results. This sort of study would have to involve statistical normalisation to conduct comparisons between different students as well.

Another insight concerns the following: the results show a clear difference between the sessions mediated by sketches and the sessions mediated by other types of artefacts such as physical or computer-generated models; the sketch-mediated sessions were significantly more abundant in reference and variety of DG categories. This is consistent with previous studies that strongly suggest that sketching is an effective tool for visual thinking and creative problem-solving (Goldschmidt, 1991). However, it could be argued that the sessions where sketches were central correspond to the early stages of the design process, when many of the critical decisions (Almendra, 2010) are still being made, and therefore, it is expected to observe more references to form-giving aspects than in later stages of the process.

Nevertheless, this insight points to the study of sketching as a useful medium to develop and communicate a common visual language between teacher and student.

¹⁰¹ However, the four case studies previously presented in this thesis do not suggest that there is a substantial difference between graduate and undergraduate students regarding design language fluency.

To conclude, overall the DGM diagrams were effective in capturing part of the content of these interactions and render it in a visual display. The resulting patterns synthesised and communicated a large amount of interconnected data that would be otherwise more challenging to grasp. For future research, the DGM could be appropriated as a basic set of categories applicable to form-giving in design, that is, other researchers might find it useful to build and expand on the category set we presented here.

Chapter 7

Discussion

Chapter 7 – Discussion

7.1 Design language

7.1.1 Meta-design discourse

Design students rarely reflect verbally on the design process during meetings with their teacher. This was the main insight that emerged from our studies. The insight has significant implications for design education, and it is possible to depart from it to discuss this thesis.

Firstly, the absence of significant verbal reflection on the part of the students stands out because it contrasts with the numerous times we observed the teachers reflecting on the design process. It is, in fact, so common that we can say that it is a regular part of their teaching performance. Design teachers spontaneously verbalise their reflections on the design process as they dialogue with the students.

During the discussions of each case – as well as in the problem statement – we pointed out that a design teacher has the explicit role of explaining the design process for the students. In other words, a design teacher, by default, has to make his thinking explicit for his students. This, of course, is not the case for the student; the situation can be described in the following manner: We assume that both student and teacher know more than they can say (Polanyi, 2009), but the teacher must actively seek to reflect aloud on the thinking that is implicit in his demonstrations, so that he models his design thinking for the student to apprehend. On the other hand, the student should be encouraged to reflect on what she knows, on the difficulties she is experiencing, and finally on the understanding that develops as she learns how to design.

So the task of the teacher is to connect what the student is expected to learn with the student's current understandings and difficulties with the design process; thus, the student's design knowledge is constructed when there is a confrontation between her existent knowledge structures and the new information arising from the practical experience in the design studio¹⁰². The teacher is thus tasked with modelling his design knowledge and experience (mostly through words) and he must additionally be able to probe into the student's current understanding of the design process to assess her particular difficulties.

This starting point may help explain the difference in discourse between design teachers and students. However, since self-reflection about the process is a part of designing (Schön, 1983), we expected that students

¹⁰² See the discussion in Chapter 2 in the section entitled *A constructivist design studio*.

would express their thinking more often even if perhaps not to the extent of a teacher.

In fact, it was an occurrence not only rare but somewhat unnatural, that is, reflections on the design process were not part of the standard discourse of the students. When a student reflected there was little continuity or elaboration. Also, during the discussions of the case studies, we considered the possibility that the students reflect while they design but perhaps may not be able to express this reflection verbally at the moment when the conversation takes place. However, if students are not able to express themselves how can teachers know if they are reflecting? Therefore, the inability to reveal their design process prevents the teacher from examining the students' thinking, and from noticing where he can help students make their process more effective and better understood.

Secondly, this result was observed with both undergraduates and graduate students. We expected that graduate students would be more fluent in design language. However, we did not find substantial differences between novice or advanced design students regarding language use. Furthermore, the dynamics of the conversations were not that different as well, that is, it was always the case that the students expressed themselves in a hesitant, insecure, and mostly unstructured speech, even when they were discussing aspects other than their design process. Also, while the graduate students we observed were handed a 'suggested methodology' to follow, this methodology did not describe how and when to apply design strategies, in other words, it described the procedural stages of a design project, but not the complexity of design thinking. We can probably safely assume that a module on design thinking would necessarily train the students in articulating their thoughts on the design process, however, would it be effective in training students to activate that ability during conversations with the teacher in the design studio?

The unclear and hesitant speech of students appears to be connected to their difficulty to articulate their design process. Thus, the studies we conducted suggest that students (novices and advanced) find it difficult to communicate their design process. This finding has another important implication for design education that we want to discuss. Our observational model is focussed on the use of language, and while the model and methodological approach were empirically centred, we do not hold an understanding of design language as merely instrumental for the dialogue.

That is, in the design studio, design language is a mechanism to mediate the conversations and to establish meaningful discussions between teacher and student; however, design language does not serve only as a communicative link between teacher and student. Granted, that is the

starting point, and in our model, we placed the language of design as a common ground in which teacher and student can begin to understand each other and in which the students learn, develop, and master the language of their future design practice.

However, language also serves to organise thought (Pinker, 1994). If this is so, what are we to make of the students' lack of fluency in design language? Students who do not reflect during practice are practitioners who have not yet mastered their craft, and practitioners, of any kind, have the responsibility of being conscientious about their practice (Arendt, 1998; Papanek, 1972; Sennett, 2008). Furthermore, to be a designer implies more than a control of the tools of the trade. We doubt that a novice designer who is not used to reflect on her practice will ever develop to become a proficient professional designer.

Mastery of design language means to be in control of one's practice. The teachers we observed often revealed an ability to stop and examine their train of thought. This ability seems to be indispensable to learn from one's mistakes and to learn from experience (Dewey, 1998). Therefore, to be able to articulate the process is fundamental to a reflexive practice.

We cannot envision a professional designer that is incapable of performing this kind of reflexion, and yet, we gather that this skill is not active in students during the moments of practice. We noted that the students appeared to be comfortable with visual modes of expression, but thinking with words naturally establishes a critical distance from the task at hand, a level of abstraction that can facilitate critical awareness of one's practice. Therefore, the ability to reflect verbally is the first step towards a more reflexive design practice.

Even if the students can reflect on their activity a posteriori none of them revealed the ability to consistently activate this capacity during design practice; Sennett (2008) claimed that reflexion is embedded in all practical endeavours, that is, it is a part of a practitioner's everyday practice. Our observations suggest that students design practice is immature, possibly irreflexive and similar between novices and advanced students. Yet, we concluded from the theoretical framework (chapter 2) that students are meant to continuously learn from the project experience in the design studio, students learn by doing while being guided by a more experienced practitioner, this is the fundamental set-up of the design studio. The conditions for learning in the design studio appear to be present, yet students do not seem to gain this capacity (for reflexion) from their experiences with the design project.

On that note, our studies suggest that the reason for students' poor performance regarding meta-design discourse is probably not exclusively linked to teacher performance. We observed five different teachers (four

cases studies and the DTRS study) and while their teaching style was different the results were similar: Grace was very clear about the learning outcomes and also intervene and adopted a hands-on approach when necessary; Ella was the more academic of all the teachers, she was very much in control and tried to get the student to get there on her own and therefore seldom demonstrated directly by drawing or modelling; Albert was the more practical teacher and often sketched to illustrate his points; Robert did not sketch but was directly engaged with the student's project; and finally, Gary, the teacher from the DTRS study, exhibited many of the traits of all the teacher's we observed and varied his teaching strategy according to the phase of the project and the student. What they all had in common was that none could get the students to consistently engage in reflection during the conversation.

The moments when the students did reflect out loud about their process were so rare that we could not detect any pattern or causal link. The fact that these reflections occurred suggests that the usual conditions of the design studio do not inhibit student reflection. On the other hand, the conditions established by the dynamics of design studio do not appear to be sufficient in their current form to elicit student reflection. The answer may be outside the scope of the design studio and found in connection with other disciplines or the overall course curriculum. However, external conditions to the design studio fall outside of our research scope.

What we can say is that, from our observations, it seems that the conditions of the design studio can be leveraged to elicit more reflection during practice on the part of the students. In fact, given that what is intended is that students can activate and express this ability during their practice, then the practical-learning context of the design studio is a suitable environment to experiment with explorative pedagogies.

It seems to us self-evident that an experienced designer is a designer who can reflect on his practice, not only after the fact but also while working. As such, we need complementary didactics that are more effective in enabling these moments, since our studies indicate that the typical dynamics of the design studio are not sufficient to nurture a self-reflexive designer.

7.1.2 Design grammar

The other half of the design language model (design grammar) revealed that students have a tendency for dispersal; that is, their design approach is fragmented, students tend to focus on one area of the project at the time and struggle to relate it to the whole design.

Here it is worth mentioning that we saw some evolution from the undergraduate to the graduate students; during the discussion of the case

studies, we addressed the possibility that this could be due to the project briefings having increased in complexity. However, while the graduate students made more connections between design elements they still had a tendency to get lost in the discussion of isolated details; we observed graduate students often being unable to relate the parts to the whole design and eventually reaching dead-ends. Also, it was usually the teacher that intervened to help the students out of the discursive deadlock, mostly by taking a step back and offering an overall perspective that refocused the conversation on the whole design.

Again we noted that the students' fragmented approach to designing contrasted with the teachers' discourse. Design teachers are constantly searching for connections between different aspects of the design project; the approach of the teachers alternate between considerations of the whole and a precise focus on details; but for the teachers, the details are only meaningful when related to an overarching idea for the design.

The students, on the other hand, were incapable of consistently doing that. Here the DTRS study was relevant in that it revealed a teacher consistently making connections between design elements. During this study, students expressed their most interconnected explanations when first introducing their ideas for the project, and then, as the conversation unfolds, the students' speech tended towards a focus on details while the teacher rarely abandoned his perspective of the whole design.

Furthermore, during their talks the teachers connected design grammar with meta-design discourse. It often occurred that both types of discourse were intertwined when the teacher spoke, a trait that we never noted in the students we observed.

Therefore, our studies suggest that during a design conversation teacher and students do not refer to the same design grammar categories to the same degree. In fact, the teacher displays a higher variety of categories than the students and consistently shows a wider range of connections between categories, elaborating on how different elements of a design related with each other and structure a coherent whole. Also, we often detected a tendency from the students to focus on one specific area of design grammar during the conversation, and disregarding the remaining ones; and this trend often resulted in the students' reaching a dead-end.

The DTRS study revealed a further insight: there was a marked difference between the conversations mediated by sketches with the ones mediated by other visual design representations (such as physical or computer-generated models). In the sessions mediated by sketches, the participants (both teacher and student) applied a wider variety of design grammar categories. The use of sketches as the mediating artefacts of the conversation correlated with a wider variety of references to design

elements. This finding is consistent with what we gathered from the literature review, namely that sketching deserves careful attention as a form of visual design representation that provides insights into the design process.

However, it could be argued that the conversations in which sketches were at the forefront also corresponded to earlier stages of the design process; since many of the critical decisions are made during early stages of the process (Almendra, 2010), it is expected that a wider variety of design elements are still being considered. Nevertheless, this insight adds weight to the notion of sketching as a useful medium in the communication between teacher and student, especially if we take into account the difficulty students feel in expressing themselves verbally.

7.1.3 The design process revealed

In the first chapter of this thesis we discussed the problem that knowledge about designing is mostly tacit, i.e. it is a form of *know how* that remains implicit in the action(s) of the designer. Since design education is fundamentally based on a tutorial between teacher and students, then the teaching/learning process relies mostly on a learning by doing paradigm. If knowledge about designing remains implicit and elusive how are teachers supposed to teach it to students who can only grasp what it is that designing means after they have done it themselves?¹⁰³

However, knowledge about designing does not remain tacit to the extent that we initially thought. Close observation and analysis of the dialogue between teacher and student revealed many of the teacher's thinking and strategies used while designing. Every teacher we observed during the case studies spoke at length about the design process, it was, in fact, a common feature of their discourse. Some teachers also engaged directly with the student's project to illustrate (and demonstrate) relevant aspects of designing. It seems clear that teacher/student interactions can be described as a practical conversation, that is, a dialogue centred on the student's project where talk is often complemented with practical demonstrations through drawing; yet, design conversations also require that knowledge about designing be rendered explicit (through words) for shared communication and reflection. Friedman (2008) noted that one of the crucial aspects of reflective practice is that "(...) reflective practice itself rests on explicit knowledge rather than on tacit knowledge." (p.155).

What does seem to remain hidden is the student's grasp of knowledge about designing. This finding poses a challenge for design education:

¹⁰³ This is what Donald Schön (1987) described as the predicament of learning how to design.

how are teachers supposed to assess and nurture students current understanding of design if they seem to be unable to articulate it? Furthermore, design educators appear to agree with a view of assessment that recognises that the process of designing should take precedence over the end-product or designed artefact (de la Harpe et al., 2009), which means that teachers must be able to disclose the student's design process from their hesitant, unclear, and at times incoherent speech.

Granted, we have mentioned before that some students can reflect (in writing) on their design process after completing their projects. However, we should keep in mind that the central teaching and learning moments occur during teacher and student one-on-one interaction. Designing, after all, is a practical activity, and students should be prepared to activate the ability to reflect on their practice as they work on their projects.

Also, some teachers were able to delve into the student's process by analysing their sketches; this suggests that perhaps the students know more than they can express verbally. Let us now move to a consideration of the role of visual design representations as mediating artefacts of design conversations.

7.1.4 Visual design representations as mediating artefacts in teacher-student interactions

Visual design representations featured predominantly in all studies we conducted regardless of course year, project stage, or type of teacher-student interaction. VDRs are as much an integral part of a design conversation as the teacher and student. Our studies considered sketches as the principal visual design representations that mediated the communication between teacher and student; from this perspective, we gathered the following insights:

Teachers often *see* more in the student's drawings than the students can express verbally. When confronted with the students' inability to explain themselves, some teachers (notably Albert [case study 3], Robert [case study 4], and Gary [DTRS study]) turned to their drawings; this strategy seemed to be spontaneous, that is, it appears to be a heuristic that teachers use as a way of probing the students' design process.

Moreover, it is often the case that the teachers' words direct the student's eye. For instance, teachers repeatedly used expressions such as: "look at it this way", "use this perspective", or "look at it from this view". Notice that, besides literally suggesting new ways to look, these verbal indications can also be a way of framing the design project from a new perspective. The teacher is inviting the student to consider a different point of view, which in turn may lead the student to reformulate the design situation.

Another advantage of focusing the conversation on the student's sketches is that the dialogue immediately refers to the project of the students. This approach made the students' comfortable and the conversation often gained momentum as a result.

We also gathered the insight that sketching can function as a laboratory to examine design ideas. This was clear during case study 3; Albert was the teacher that sketched more often during the design conversations. These sketches functioned as a shared mental model (Goldschmidt, 2007) of the design that teacher and student explored together. This exploration is beneficial for two reasons: on the one hand, it allows experimenting with solutions quickly and without cost, on the other hand, it is a direct engagement with the project, therefore, during these moments, the student is experiencing the process of design as it might unfold in a professional setting.

The teachers also used sketching to illustrate and complement what they were explaining verbally. This was observed with Albert and Gary, particularly the former. Albert insisted on underlining his explanations with spontaneous sketches that he sometimes drew over the student's drawings. On a similar note, but regarding physical models, we saw Ella and Grace (and also Gary during the second conversation with the student Todd) directly manipulating the student's model to illustrate their explanations. Unlike the students, the teachers had no problem alternating between visual and verbal modes of expression.

Additionally, Grace (case study 1) and Albert (case study 3) insisted that the students should use visual design representations as artefacts to explore design ideas (McNair, Piretti, & Groen, 2014). Both teachers conveyed the notion that VDRs are not merely representations of an artefact-to-be but instead, should be used as generative and, most of all, explorative parts of the design process. Grace was particularly clear about this function of VDRs; for her, to explore the model as a thinking tool was more important than to create a perfect representation of reality.

We have discussed design language and visual design representations which are an integral part of the design conversations model. Let us now discuss more general insights that emerged from our studies, namely those concerning the dynamics of teacher-student dialogue and how the teaching/learning process unfolds.

7.1.5 Teaching/learning process – dynamics of the interaction

DESIGNING TOGETHER

Design conversations are essentially dialogues, but not between peers. A quantitative analysis of the verbal output of the participants consistently

revealed that the teachers spoke longer and used longer sentences than the students. The teachers are in control, often changing the direction and focus of the conversation.

The exception was when the teacher engaged with the student's project, and both participants worked together. In these moments of the conversation, the teacher fully engaged with the project at hand, as a senior designer might in a professional design studio.

These moments of teacher and student designing together are pedagogically interesting; the student witnesses the teacher posing questions, raising possible solutions, and exploring the design situation. As teacher and student work together, the initial conditions and constraints of the project shift, new ideas and solutions emerge and call for a reformulation of the problem's boundaries. This exploratory approach is an approximation to the real practice of designing and therefore a valuable experience for the student.

However, it is difficult for the student to manage the sudden instability of a design situation.

THE INDETERMINACY OF THE DESIGN SITUATION

Design teachers are entirely at ease with the intrinsic indeterminacy of a design situation. By indeterminacy, we mean that each design situation is unique and there are no perfect solutions for a design problem, only better or worse ones, which renders the design process – to a greater or lesser degree – unpredictable.

Instability is naturally present in the early stages of a design project. However, teachers seem to be comfortable in recreating these conditions in later stages, that is, while instability is typical of a project's early stages, the teachers continue to recreate these initial conditions as the project progresses. In fact, teachers often searched for opportunities to reformulate the boundaries of the project (see particularly Robert from case study 3). This eagerness to reformulate the project's presuppositions is consistent with what we know of the performance of expert designers (see chapter 1), who seem to create ill-defined conditions even as the initial project conditions evolve and become more stable and definite.

The students, on the other hand, revealed to be more comfortable in a controlled, well defined, and established design situation; we often observed that students were at their most fluent when first presenting their ideas, and then, as the conversation unfolded and the teacher suggested different perspectives, the student's discourse grew elliptic, hesitant, and insecure.

Design conversations are a form of design activity, and design activity

is by nature ill-defined. Therefore indeterminacy is an integral part of a design conversation. Teachers seem to be more comfortable with this built-in indeterminacy than the students, to the extent that when the conversation became too stable, (or too narrow) the teachers often took a step back to reformulate the boundaries of the design situation (see teachers Robert and Ella in particular). This strategy was often marked with the expression “imagine that”¹⁰⁴

DESIGN CONVERSATIONS ARE GENERATIVE

Design conversations can provide the conditions for a generative dialogue in which the project changes but also the design process of the student becomes more intricate, complex, and explorative. Here, the role of the teacher can be vital.

In case study 1, for instance, Grace was able to guide Dylan (the student) from an initial stance of some restraint to an exploratory approach that grew during the interaction. As a consequence, the project developed quickly and the student’s process became more exploratory. Also, during case study 2, we observed how a simple suggestion (to spread all her drawings in a large table for analysis) from the teacher Ella enabled Janis to make choices that overcame a dead-end and propelled her project forward.

Therefore, a design conversation can have a direct impact that changes the student’s approach to the design process; but also, practical engagement with the project during the conversation can generate new ideas that unlock the process, reframe the design situation, and enable the student to move on with the project.

DESK TUTORIALS, CRITS, AND REVIEWS

Our theoretical framework includes a taxonomy of design conversations. In this taxonomy, we propose that there are important differences between conversations in which a teacher actively designs with the student (desk tutorials) or mostly examines the student’s design project (desk crits or reviews).

A review is a more stable type of design conversation in which the conditions do not change considerably. However, during a review, we saw how a teacher may still engage with the project to some extent. In these moments, the conversation shifts to a desk tutorial dynamic. Case study 2 was an excellent example of a tutorial that quickly turned to a review only to end as a tutorial again. While it was useful to define clear categories (to

¹⁰⁴ Such as in case study 3 when Robert challenges Patti with the metaphor “imagine that you’re designing a teapot”.

help us determine what we were observing on the field), it is necessary to keep in mind that there is considerable overlap between these three categories.

During desk tutorials the teachers actively participated in the student's project; in these moments, we gathered that they often had trouble to disengage, and only stopped when noticing that they had gone too far and were in fact solving the problem for the student (see the example of case study 3).

7.1.6 Limitations of the studies

The first limitation of the research studies we want to address is the low number of participants. We selected a case study methodology to explore the design studio because the literature review indicated there were still substantial lacks in our understanding of its setting. The case study method focuses on individual cases and analyses them in depth, the findings allow us to begin to disclose patterns based on empirical observation; but the next step is to replicate the findings of the studies with larger samples.

Also, our studies are four cross-sections of the design studio, which means we did not analyse the effects of design conversations in the long term. For that, we would have to follow and observe the same student(s) across time. This means that we analysed the impact of developments during the conversations, but not how it impacted the student's learning regarding their long-term evolution as designers. The studies go as far as establishing a foundation for longitudinal studies to be conducted.

Secondly, our unit of analysis was the teacher-student dialogue; but design language can also be expressed visually¹⁰⁵ (through visual design representations). As such, it is a limitation of this study that we did not analyse the student and teacher's visual output together with the verbal analysis. A parallel analysis of the visual and verbal dimensions has the potential to provide a more accurate description of how design language operates.

A focus on verbal output also revealed an insufficiency of our observational model that is connected with our findings: since we focused on verbal analysis and the students have trouble articulating their thought processes, then the model did not reveal significant insights about the student's design process.

¹⁰⁵ Design teachers seem to be aware that design language can be both verbal and visual, since, as we pointed above, they often surveyed the student's sketches looking for information they were not able to grasp from the student's verbal expositions.

7.2 Research questions

In this section we will recapitulate and answer the research questions. The questions are the following:

1. What is the result of design conversations?
 - Do design conversations reveal new knowledge about design and designing? If so, to what extent do students reveal they have apprehended it?
 - Do design conversations influence the design project?
 - Do design conversations influence the student's design process?
2. What is the role of design language in design conversations?
 - Does the design language model reveal the design process of teachers and students and render it more explicit?
 - What are the differences and similarities between teacher and student use of design language?
3. How do the defining features of the design studio influence the dialogue between teacher and student?

7.2.1 Research question 1: what are the results of design conversations?

We will begin by addressing the subquestions:

*Do design conversations reveal new knowledge about design and designing?
If so, to what extent do students reveal they have apprehended it?*

The goal of a design conversation is pedagogical, that is, its purpose is to provide the student with a fruitful experience of a design situation. We have seen how the format of design conversations encourages the teacher to make his thoughts and reflections about design explicit for the student to apprehend. In doing so, the teacher models how a designer thinks and works; by making his views clear, the teacher presents templates on how to conduct the design process in the future.

The teacher illustrates the practice of designing through words and actions. These illustrations represent more than just information about design. Information may be stored on a computer or an archive of any sort, but only a human being can be said to embody knowledge (Polanyi, 2005). Information (data, facts, or parameters) can be stored but knowledge is embodied, in other words, it is acquired through experience and becomes a part of a person's inner world.

Knowledge about designing is practical, that is, it consists of behavioural patterns embedded in personal action, as well as facts and information allocated to long-term memory (Friedman, 2008). That is partly the reason why knowledge about designing is often considered tacit knowledge. It is an individual kind of know-how, which means that the teacher, in making his thoughts about designing explicit, provides the student with an account of his unique design experience and personal take on designing¹⁰⁶.

If every design teacher's take on designing is to some extent unique, then design students could potentially benefit from meeting many studio teachers during their years in a course. In doing so, students would have a varied experience of what design is and how to do it.

In short, during a design conversation the teacher articulates his (mostly) tacit knowledge about design verbally for the student to apprehend. This knowledge may not represent new knowledge for the field of design as a whole, but it probably represents new knowledge for the student. So, the answer to the question is yes – design conversations can reveal new knowledge in two ways: (1) knowledge about how to design that is modelled for the student; and (2) unique knowledge about designing, or the teacher's personal take on the design process.

We should note that the articulation of implicit knowledge to the more formal medium of words and language depends on the teacher's ability, experience, and ease in communicating verbally. Also, since a conversation is not recorded it is immediately lost, that is, the words are spoken and hopefully apprehended by the student, but they cannot be revisited. This is interesting from the point of view of design research in the following sense: countless design conversations occur every day in design schools across the world; these conversations illustrate unique approaches to the design process which means that a systematic documentation of these encounters could provide robust empirical data for future theoretical work .

The second half of the question is:

to what extent do the students reveal they have apprehended it?

Our research does not satisfactorily answer this question. We would have had to follow the same student(s) across time to observe what was the long-term impact of the teacher's tutorials. To gather and analyse longitudinal data and determine causal links would also require specific research methodologies.

¹⁰⁶ We have seen in Chapter 1 how design can be described as a situated activity where each problem/solution pair is unique, which means that, more often than not, designers have their particular ways of dealing with ill-defined situations.

The issue that underlines this question concerns the influence of the teacher on the students' maturation as designers. Intuitively, we suspect that there must be an influence and that some teachers have a more positive impact than others; but how can we assess and measure that impact? And to what extent is the impact revealed by the students' discourse or by the outcome of their projects?

We should highlight that it is difficult to draw a direct line between what the students reveal (through words but also through the outcome of their projects) and what they know (Polanyi, 2009). This issue concerns a critical aspect of design education: design education should be process oriented rather than product oriented (Ledewitz, 1985) since focussing on the final product determines definable criteria for evaluation, but it does not account for how the students' design process unfolds.

The studio establishes incremental stages that progress from a formative (initial tutorial sessions) to an evaluative (a final presentation) character. From session to session the student incorporates the teacher's advice, abandons ideas, reshapes initial conceptions, expands her perspective and understanding of the problem, and integrates these aspects into a design solution. It is through this step by step process that the student's knowledge grows.

During this process, the teacher should identify moments when the student reveals parts of her design thinking through words or actions; then, with each conversation the teacher can slowly examine what might be missing in her thinking and design approach. Future research could be aimed at providing teachers with tools to support this important pedagogical task.

Let us now address the next sub-questions:

Do design conversations influence the design project?

Do design conversations influence the student's design process?

We would have been surprised if design conversations did not have an impact on the student's design project. The question should be answered in terms of how, what kind, and in what circumstances do design conversations influence the design project. Also, we will address both questions in the same answer because the design process and the design project are linked, since the project is where the design process is enacted.

All four case studies provided examples of the impact design conversations have both for the students' project and their design process.

In the first case, the teacher gradually guided the student towards a solution for the train station he was designing. In the beginning, the student was focused on secondary aspects of the station (technical

details concerning train lines) but as the conversation unfolded, the teacher anchored the student's attention to the model and encouraged him to adopt a broader perspective for his design concept. Throughout the conversation, the student expanded his perspective and – with the guidance of the teacher – made decisions and integrated them into his design solution. In the end, the project advanced considerably from the point where it was when the conversation began.

At the same time, we realised that the student's project evolved also because the teacher encouraged him to experiment with a different way of designing, in other words, to adapt his design process. Therefore, we observed the student moving from a detail-focused approach to a consideration of the whole design (a perspective that the teacher suggested was more appropriate for that phase of the project). The student gradually altered his approach to the design and the project progressed throughout the session.

The second case is also an example of how the teacher guided the student to make decisions that had a direct impact on her project. In this case, the student admitted at first that she was stuck and unable to move forward; then, the teacher suggested that it would be easier to make decisions if she took a more general perspective of her work. The conversation that followed allowed the student to make choices and move on to the next phase of the project. This case is similar to what we observed in case 1, in that an alteration of the approach to the design process resulted in progress for the project.

Case study 3 was different. We observed the teacher increasingly involved with the project as the conversation unfolded. The teacher analysed the student's work and proposed a synthesis himself; then, a solution for the project naturally emerged from the dialogue, but it was the teacher who suggested and outlined a design concept, and not the student that arrived at a solution. That is, while in the previous cases the teachers lead the students to make their own choices, in this case, the teacher suggested a solution himself. Therefore, the project evolved and changed, but for different reasons. It is interesting to reflect that, in this case, there was no observable change in the student's design process. It was the teacher who provided an example of how to proceed; he took a step back and, from a general perspective, proposed a synthesis and reached a specific solution for the project.

Finally, in case study 4 we cannot claim that the student's project changed in to the same extent as the previous case studies. There was a gradual evolution from the beginning to the end of the conversation, but we did not observe a decisive leap as in the earlier cases. However, the conversation was long and the involvement of the participants with the

project was clear. Also, during the conversation, we noticed a difference between the student's and the teacher's way of looking; that is, the student remained focused on details and particular solutions, while the teacher was more comprehensive, more global, always searching for a general concept to tie the loose ends of the project (a pattern we observed in all design teachers).

Thus, we note that design conversations can have a determining influence on the student's project, but they can also have a more gradual impact. Our studies indicate that, to a greater or lesser extent, the conversations result in a change in the conditions of the project. The gradual follow-up that the setting of the design studio provides seems appropriate because it allows the teacher to manage his involvement in the project according to the student's needs. On this note, the teachers should pay particular attention to milestones (the moments when critical decisions must be made) and moments of stuckness, i.e. when the student finds herself unable to proceed, as moments when there is a high potential for the project to evolve.

Considering the design process, it seems that for a teacher to influence the student's process a clear rupture may be necessary. In cases 1 and 2 (in which a change in the student's process was more evident) both teachers suggested that the students should adopt different ways of looking at the design situation therefore encouraging them to frame the project differently.

A change in perspective often correlated with a change in the student's design process. Indeed, new ways of seeing the situation resulted from a momentary lack of control on the part of the students. In general, the students arrive at the conversation with the project constraints clearly defined and established, as if they had an exact map for the unfolding of their project; but the map leads them nowhere (all students were, in varying degrees, stuck in their process). In a way, teachers tore the student's initial map and pushed them further into uncharted territory, while encouraging them to find new ways to guide their journey.

This placed the students in a situation of uncertainty, lost and no longer with a map for their destination, they had no alternative but to consider new ways of doing, alternative solutions, and different design approaches. To experience uncertainty can be fruitful for a student's learning, Piaget (Flavell, 1963) considered these moments decisive for the construction of new knowledge (instead of uncertainty Piaget called the moments when encountering information that requires the construction of new cognitive schema as *disequilibrium*). In addition, this uncertainty allows students to experience the natural instability of the design process, and by doing so, learn to manage it.

7.2.2 Research question 2: what is the role of design language in design conversations?

This question includes the following interrogations:

Does the design language model reveal the design process of teachers and students and render it more explicit?

What are the differences and similarities between teacher and student use of design language?

The role of design language is addressed in detail in the previous section (7.1 Design language;) and we discussed the disclosure of the design process in the answer to the first research question. Concerning the differences and similarities between teacher and student's use of design language, during our research, this question grew in importance and became an important focus point for the thesis. As such the research design and analysis meant that we strongly focussed on design language use and this question was also extensively discussed in the previous section.

7.2.3 Research question 3: do the defining features of the design studio influence the dialogue between teacher and student?

The defining features of the design studio are detailed in chapter 2 of this thesis, where we summarised its elements in a model. The model has three levels: (1) design studio, (2) format of design conversations, and (3) design language. It is important to emphasise that the focus of our research is teacher/student interaction, so our studio model places the interaction at its centre, but different theoretical perspectives may identify other features of the studio as determinant.

Levels 2 and 3 concern the dialogue and language used and were addressed in the previous section. We will summarise how they are constituted and then move on to a discussion of the first level (design studio) of the model in more detail.

We described the format of design conversations as a teacher and a student having a one-on-one conversation mediated by visual design representations (VDRs); the dialogue concerns the student's project, and the VDRs are the outcome of the participants' modelling. Design language is the visual or verbal expression of the design process used by teacher or student during their conversation. It is a language of practice since a design conversation takes place in the context of working, presenting, or reviewing the student's project. This point was explored in the previous section where we analysed the discourse of both participants in detail.

We will now address the first level of the model in more detail. The first

level details a teacher/student interaction taxonomy whose categories vary according to three axes:

Informal – formal;
Formative – evaluative;
Private – public.

Our studies are examples of more informal, formative, and private conversations. This type of conversation (that we termed *desk tutorial*) establishes the conditions for the student to gradually engage with the dialogue during the meeting with the teacher. The purpose of a desk tutorial is not to evaluate a deliverable or a specific outcome of the project, in fact, the purpose of the conversation is simply to *talk*, that is, to openly discuss the project and explore ideas.

The first case study is an example of how these conditions provide the opportunity for the student's engagement to grow during the conversation; in this case, the conversation was spread throughout the entire session. The short episodes that constitute the whole discussion are interspaced with more extended moments where the student works on his model. As such, we noted that the teacher's advice is immediately tested and integrated into the student's project, in a *talk-testing-talk* dynamic. In a more evaluative and formal setting this dynamic would be less likely to settle.

The second case study had a similar dynamic but not to the same extent. In case study 2, the conversation was divided into two halves. In the second part, we observed the student incorporating the advice that the teacher gave in the first part of the conversation, which indicates that the interaction with the teacher directly impacted the student's design process.

The studies with graduate students revealed a different teacher/student dynamic. While we cannot state that the meetings were formal, there was a clearly delineated beginning and end (both teachers had assigned time-slots to each student before the class) to the conversation. This point on its own already contributes to a different dialogue dynamic since the students cannot go back to work and return for further feedback during the same studio session.

However, it is important to take the following aspect into account: graduate assignments were more complicated because the briefing was an approximation of a real-world design assignment. Therefore, considering the project complexity was higher, it is harder to expect the students to complete a small task or address a particular aspect of the project (or their process) in a short period of time. The undergraduates, on the other hand, dealt with a project that had fewer implications; the purpose was to let

the students experiment and explore, and to complete simple 3D models with only a limited correspondence to any real-world constraints.

Therefore, it seems that the complexity of the project can have a significant bearing on the dynamics of the conversation. Nevertheless, a teacher that wishes to obtain a more immediate reaction from their graduate students may try to set up short-term goals for the session as a strategy to move the project forward. This observation is related to our next point.

We noticed that the teacher controlled the formative/evaluative axis of the dialogue. A conversation may begin as formative, but the teacher is always in a position to introduce the evaluative aspect of the dynamic. The second case study was an example of this situation; recall how the teacher advised the student to display her work in a layout that facilitated assessment and appraisal, thus focussing their conversation on a consideration of the strengths and weaknesses of the student's work, i.e., a more evaluative dynamic.

Also, a teacher can introduce an evaluative level to an informal conversation by reminding the students that there will be a moment of evaluation and recall the grading criteria, expected deliverables or deadlines to be met. For instance, in case study 3, the teacher referenced the number of concepts that the student was expected to turn in, and in case study 1, the teacher often mentioned the deliverables and evaluation criteria of the final project.

Thus, a design conversation can alternate between its formative and evaluative poles, therefore underlining the double role of the teacher as a tutor and evaluator.

Another feature that has an impact on design conversations is the stages of the project. It is different to have a meeting in early stages of the project or to meet the students in later stages when the pressure from an imminent deadline is felt. Different stages of the project correspond to different ways of thinking. Designers tend to think divergently in earlier stages of the design process (Almendrea, 2010) and then progressively alternate between divergent and convergent modes of thinking until a solution is reached.

For instance, in case study 2 we found the student stuck in a critical decision-making phase between two stages of her project (in her case, switching from two to three dimensions). This constraint was decisive for the unfolding of the conversation; the student had to make a decision in order to move forward with her project, which meant the conversation was centred on the teacher guiding the student in her decision-making process.

We made similar observations during the DTRS study cases. In later stages of the project, the talks were less affluent regarding design language and also shorter; whereas conversations held in early stages of the design process were more expansive, with more extended discussions, and included exploration of different ideas.

Chapter 8

Discussion and Recommendations

Chapter 8 – Conclusions and recommendations

Opening remarks

This chapter has two parts: the first part is a broad discussion where we suggest how design education, research, and practice may be connected. In the second part, which is more narrow in scope, we will describe guidelines for the practice of design teachers in the studio and also for researchers that aim to study the design studio itself.

We begin with a discussion that explores the gaps between design research, education, and practice, where we describe how design conversations can represent a moment of convergence of these three dimensions of design. However, while these three aspects can often overlap, the scope of this thesis means that our conclusions are primarily relevant for design education and research, and only marginally applicable to design practice.

8.1 The design studio – the meeting of design education, research, and practice

8.1.1 Summary of design education

Let us recall one of the questions proposed in the introduction of this thesis: *How does the teaching/learning process of design unfold?* The model for design education is the design studio, an educational setting where students practice designing under the supervision of a teacher. In this setting, one-on-one meetings between teacher and student take centre stage, and it was precisely in this context that our research was centred.

An often overlooked aspect of teacher-student meetings is that they are a conversation – a close and personal dialogue about the student's unfolding design project. While student activity in the studio can be considered another form of design practice (or at least, a simulation of the real thing) the dialogue between teacher and student is a unique aspect of design education. Note that, in their everyday professional practice, designers do not usually talk about their design process and when they do it is often in mystifying terms. As it happens, knowledge about the design process is commonly described as tacit, implicit, intangible, hard to be known, and so on. However, we have seen that, on the contrary, the studio places the teacher in the position of having to make the process of designing clear and explicit for the student. This situation was evident in our observations, where talk about the design process naturally emerged from the conversation with the students, thus challenging the belief that knowledge about designing is intangible.

Often short and spontaneous, these everyday conversations form the backbone of the teaching/learning process in the studio. One by one,

each dialogue adding to the student's growing experience with the design process. Countless such meetings in numerous design schools take place across the world every day, which makes the purely evaluative moments (final or intermediary project presentations) the exception in the otherwise tutorial-based daily activity of the studio.

In fact, while these conversations support students with their design process (the formative aspect), they also have a cumulative element in the student's overall evaluation as a step-by-step assessment of their evolution in dealing with a design project. This means that design pedagogy is process-oriented and not product-oriented since the purpose is to learn from the experience of designing.

Therefore, the dialogue in the design studio forms a formative–evaluative continuum where learning and evaluation happen simultaneously with each conversation. This teaching/learning process is becoming ever more unusual in the current day metric focused university. As such, while we consider the pedagogical underpinnings of the design studio as valuable and unique, its benefits are not immediately evident to an outside observer. If the design community wishes to preserve its natural educational setting, then we must be clear about what makes it valuable by studying and defining it in its own terms.

8.1.2 Particular and universal

Our studies of design studio conversations provide a detailed account of cases of studio interaction. While the interest of such an analysis may be immediately relevant to any design teacher, we will argue that the importance of design conversations is not limited to the practice of teachers in the studio. Instead, taking a global point of view, we find that design conversations have a significant impact on design education as a whole.

Still, considering that our empirical work is centred on a private and personal phenomenon, how can we extend the conclusions to make them relevant to the general fields of design education and research?

The everyday conversations taking place in the design studio between teacher and student are (in varying degrees) a private and personal matter. Not only are the constraints of each project variable and unique, but also the ways to approach and conduct the design process are particular to each student, and furthermore, every teacher–student pair is made up of two distinct individuals. Thus, the object of study of this thesis is centred on a private, personal, and unique universe.

However, we have described elsewhere how there are features of design conversations that are constant, that is, each conversation takes place within a format in which the fundamental premises are the same: teacher and student discussing the design project in a conversation mediated by visual design representations. Therefore, we notice how design conversations alternate between localised issues directly related to a

student's design project, and also a meta-discussion about designing in general. Thus the set-up of the dialogue means that teacher and student focus in turn on the particular and the universal, which means an analysis of the dialogue can reveal both broad themes and more practical ones concerning design instruction.

It follows that by examining the personal interactions we also disclose aspects of and raise questions connected to design teachers and design education in general.

This observation has implications for design research. Accordingly, we will argue here that design conversations are not only crucial for design education but also relevant for design research. In fact, we suggest that design conversations can be a situation where the strands of design research, education, and practice can converge.

8.1.3 Introducing research results and theories into the conversation as part of the tutorial

Design teachers can present design research findings to students as a part of their feedback techniques; teachers may, for instance, introduce tools to support the student's design process. This activity could become another part of the typical formative-evaluative continuum of the studio since the teacher can assess if the students integrated this information into their practice and if it was useful for their projects. In this way, research-based theory, techniques, and tools can be integrated within the usual tutorial activities of design teachers.

Thus, students engaged in the usual learning-by-doing activities of the design studio could also be exposed to specialised areas of knowledge considered useful for design and exposed to the degree that they can apply that knowledge into their studio projects.

Furthermore, the studio could provide theoretical work conducted by design researchers with a much needed empirical basis for the testing of hypothesis, or for the exploration of theoretical concepts, in short, the studio could function as a laboratory for design research. By laboratory we mean that the studio can be an experimental setting to test research-based theories and tools as well as a setting to explore and examine teaching strategies.

We can recall here the observation of Donald Schön (1985) in that the author called for reflective practice as a way to integrate theories and techniques resulting from design research within the established advantages of the studio educational system (with its foundation on a personalised teaching/learning experience, practical learning, learning by doing, and so on).

Also, the integration of research into the studio may be adequate for the teaching of design since design is a practical activity that requires applied knowledge. That is, while theory-making is not a goal of design activity

(because designing is inherently practical) design is also a synthesis of know-how and skill, together with applicable knowledge of science and technology, sociology, psychology and increasingly of cognitive science as well. While information relative to these knowledge areas can be taught outside the scope of the studio, it is perhaps more suitable for the goals of design that that knowledge is made operational and useful when applied to the students' projects.

Integrating research in the studio also addresses the problem of separating theory from practice and analysis from designing. Notice how abstract research results and theories seem distant from the particular know-how that we have seen design teachers employ in their everyday studio practice. Integrating research results into the traditional culture of the design studio can make the growing body of theoretical knowledge operational, applicable, and connected to design activity.

8.1.4 Analysing design practice

Integration of the results of design research into the studio is one way of connecting research and education. However, we would like to explore another possibility: the potential of the studio as a place where research *about* design practice can occur.

Thus, a secondary purpose of the studio could be to question and analyse the practice of design. While the specific constraints of professional design practice may be incompatible with the time-consuming effort of rigorous research, in a university this kind of analysis is expected. After all, critical thinking and self-awareness about one's practice are desirable skills that any higher education degree should foster in its students.

This conception of the design studio has implications for the kinds of research that can be more fruitful to conduct in the studio. Firstly, knowledge about design may be disclosed via careful observation of design conversations, since we have observed that teachers try to make their knowledge of designing clear and explicit for the students. This approach would follow similar lines to the ones adopted by the studies presented in this thesis.

The above suggestion implies the presence of a third element (the researcher) studying design conversations; however, an alternative form of analysing design practice implies that both participants can, in turn, explore the context of their interactions to conduct personal reflections on the unfolding design process. In other words, both student and teacher may take the opportunity provided by the design studio to practice their self-awareness about designing.

The issue is how to operationalise this call for reflection? Since we observed that students have a hard time verbally expressing their design thinking, fostering the students' capacity for reflection, analysis, and communication should require the development of specific studio didactics.

8.1.5 Discovering new knowledge: the difference between research and learning

In addressing the educational design studio as a centre to conduct research, it is essential to make a distinction: in the studio, design students learn how to design, but learning, while generating new knowledge for the learner, is not, however, the same as academic research.

Knowledge creation alone is not research. Certainly, learning how to do something creates (new) knowledge for the learner, and practice develops the skill of the practitioner, but research is meant to create knowledge for the broader community as a whole.

This mixing of *learning* and *research* may emerge because the design process usually has a research phase, and designing, in general, is accurately regarded as a form of exploratory inquiry into the artificial world. However, neither the design process as a whole nor its research phase are the same as the research undertaken, for instance, to earn a PhD (Rugg & Petre, 2004), because research conducted during a design project usually results in new knowledge for the designer, and rarely for the discipline of design in general.

Without this distinction, we may fall into the misconception of equating any form of knowledge generation as research (Friedman, 2008; Langrish, 2000)ⁿ. It is essential to keep this in mind for anyone deciding to go into the studio to conduct research and also for design teachers wishing to engage in research about their teaching practice. The studio is a setting where new knowledge that is relevant for the community can be obtained, namely about the design process and also about design teaching and learning. However, this inquiry should adhere to the standards of academic research of being a studious inquiry and methodical search for knowledge that can be communicated and is useful for the community.

Therefore, making the design process explicit is not a sufficient condition for research in the studio; the resulting information must be systematically gathered, organised, and analysed to be able to be communicated with others and eventually replicated.

8.1.6 Teachers/researchers

In the studio, it is imperative that teachers become expert tutors in control of their teaching practice. Studio teachers require expertise in design teaching that is related to the practice of designing, to be able to accompany a student's first steps to becoming a designer. This is a complicated set of requirements that is not helped by the fact that, at the moment, the necessary skills to be a studio teacher are rarely communicated to others. Not because of any known unwillingness on the part of design teachers but rather because this is an understudied area of design education.

As such, novice design teachers must develop their teaching heuristics on

the spot.

Herein lies the opportunity for the design studio to be a place where teachers research and reflect about (their) design teaching. However, there is a problem inherent to this imperative: like all practical knowledge (Sennett, 2008) the teacher's tutoring ability develops slowly from the many encounters with students until it becomes implicit in his actions. The difficulty is that mastery of skill necessarily conceals from conscious awareness an essential part of the mechanisms inherent to its practice (Polanyi, 2009).

This is a deep-rooted difficulty of design education: the fact that teachers, besides being faced with the predicament of having to make explicit their inherent design practice, must realise that their teaching practice has also become heuristic in nature. In other words, it is difficult to provide explicit, accurate, and useful accounts of design teaching best practices, since, much like designing, tutoring skills have become second nature and intuitive.

Therefore, the difficulty for the teacher is to perceive as new a practice that has become implicit. To achieve this, the teacher must deconstruct his tacit knowledge about teaching through analysis and self-awareness. Also, the outside observations of researchers may provide fresh insights that are not immediately evident, and finally reading accounts of other design teachers' teaching practice may help to determine successful teaching tactics and best practices.

As such, studio teachers should conduct systematic descriptions of their everyday tutoring that may be useful to novice teachers who are beginning to teach in the studio.

However, most design teachers presently have a double role as design researchers, and the rising demand to publish research results will invariably impact on the quality of time spent teaching design. On the other hand, this problem could constitute an opportunity if teaching and researching form a common area of interest; for instance, by making teaching practice the focus of research. In other words, if part of the activity of a design studio teacher was to monitor, reflect, analyse, and present the results of his teaching practice.

Going into this thesis, we noted that there were no comprehensive guidelines for design teachers who first enter the design studio; learning how to teach design is done on the spot by doing it and observing more experienced teachers (in a process curiously similar to the one experienced by design students first learning how to design.) Which leads to the conclusion that knowledge about everyday design teaching should be more explicit.

Thus, it is crucial to develop lines of research in universities for research on the practice of teaching and learning in the studio. These research studies do not necessarily have to be of a highly theoretical nature but focus instead on empirical explanations of implicit teaching practices. The

call is then for studio teachers to systematically reflect on their teaching practice, so that a comprehensive pedagogy of design may develop from the convergence of many personal teaching experiences. In this way, knowledge systematisations about design teaching can emerge, step by step, in the form of guidelines, feedback techniques, and best practices that could be useful for novice design teachers.

Such systematic inquiry can be beneficial for design schools as they examine their curricula, particularly as the faculty balances the necessity of studio learning with research demands. It is self-evident that design schools would benefit from a thorough understanding of their teaching traditions and specific know-how. As design grows in complexity, research in adjacent fields such as sustainability, design for well-being, or co-design develop into their specific sub-fields and expand the body of knowledge of the discipline of design. Integrating these strands of knowledge into project work can only enrich what is already a valuable and unique teaching/learning experience. This integration is also paramount if we wish to avoid unnecessary fragmentation and sub-field insularity.

As the contemporary university becomes increasingly metric-centred (mainly focussed on publication aggregates and competition for grant resources) it is important not to lose track of the essential. Design schools should maintain the balance between normative curricula and education in practical designing, and the studio could be the place where both these sources of design knowledge converge; seeing that the studio teachers reflect on their performance and rigorously account for this in the form of research that could be made explicit and therefore easier to communicate to others.

To sum up, design education can preserve its idiosyncratic teaching template (the studio) and still move forward as a rigorous discipline that investigates and integrates the results of its research into practice and teaching.

We conclude the chapter with a series of recommendations for future research on design education and design teaching practice.

8.2 Recommendations for design studio teachers

In this section we present some recommendations for design studio teachers. The suggestions follow from the study outcomes but also from our observations of teachers in practice and what we gathered from the theoretical exploration. The recommendations should be read as guidelines for teachers, not as recipes or infallible directives. Experienced studio teachers may already apply some of these recommendations in their teaching, nevertheless, it could be useful to see their heuristics explained and supported by empirical research.

- Design students (both novice and graduate students) seem to have, to a greater or lesser degree, difficulty to verbally express their reflections on the design process. Teachers should be aware of this pattern and concentrate on understanding if this difficulty is due to lack of self-reflection on the students or an inability to verbally express it. There are tried and tested procedures that require the students to reflect on their design process a posteriori (such as post hoc reports), but our recommendation is for the teachers to encourage students to practice self-reflection during – instead of after the fact – the conversations in the studio.
- Taking into account the difficulty that students show in expressing their (design) thinking, consider adapting the interaction according to the particularities of each student. It may be interesting to look for alternative ways of encouraging students to speak to express their design process. Some students may reveal aspects of their process mostly in their drawings, sketches, and through physical and virtual models; while others are more comfortable when engaging in dialogue. Also, during the dialogue, it is critical to understand if the student is listening. Seek ways to make the students engage in the discussion so that they may contribute with their input. This engagement is crucial for the student to actively experience the typical unpredictability of a design conversation.
- Guide the students to make connections between thinking and actions, in other words, connecting the process of design with the project of design. Concurrently, be attentive to verbal queues of the students; if the students express thought then try to get more out of them.
- Prioritise a focus on process instead of end product. The students are naturally focussed on the end product since their concern is towards finishing on time and obtain a good grade. What they lack is an awareness of their design process.
- Practice self-awareness regarding the types of discourse (meta-design discourse and design grammar) used in the studio; when to use one or the other aspect and when to intertwine both.
- Since time is a valuable resource, it is worth managing studio time to get the most out of the individual meetings with the students. As such, we recommend more meetings should take place shortly after the project began and the student has completed preliminary work, explored ideas, but has not yet settled on any definitive directions for the project.

8.3 Recommendations for future research

In the discussion chapter we addressed how the studio could serve as a setting to conduct design research; the chapter presented a broad discussion and highlighted potential directions for future research. In this

section, we present specific suggestions for design researchers that follow from the outcomes of our studies. As with the previous point (concerning studio teachers) the suggestions are succinct and should not be taken as instructions but rather as guidelines.

- The language of design we used as a frame for our empirical observations can benefit from an expansion and refinement of its categories. The design grammar, in particular, could be extended to include other categories than the ones we used for our study. The proposed model should be understood as a foundation to build upon.
- Replication of the case studies we presented could provide empirical weight to design education research. The methods used are documented in detail also to encourage other researchers to apply, alter, or expand them according to specific research contexts and needs. More empirical studies focused on the design studio are needed, and the case study method we applied seems to provide relevant insights.
- Future studies conducted using the framework presented in this thesis could centre on a complete project as another element of the analysis. That is, more insights could be obtained if we follow the same teacher-student pair during the development of the entirety of a student's project (for instance, during a semester-long project). Thus, one way to build on the research we presented here would be to conduct longer case studies with the same subjects. However, it is worth advising that the limitations and difficulties we documented along this research are likely to be accentuated in a continuous study.
- Another possible study could focus on exploring if there is a correlation between exceptional students and use of meta-design discourse. Whether or not it is important for a design student to be able to express meta-design discourse can be determined if there is a correlation between outstanding students and consistent use of meta-design discourse while designing.

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Summary

The purpose of this thesis is to describe the process of teaching and learning how to design. Knowledge about design education has thus far lacked a foundation in empirical studies. As such, the thesis is built by four case studies conducted in real-context settings; the case studies are direct observations and analysis of four different teacher/student interactions including graduate and undergraduate design students. An observational study from a video-database of nine teacher/student conversations complements the case studies' findings.

The format of teaching and learning how to design is a dialogue that takes place in a design studio. The exchange is conducted by teacher and student while focusing on a design project; this is so because the design studio is a practical educational setting where students learn by doing, that is, by designing under the supervision of a design teacher.

The title of the thesis – design conversations – is the term we propose to describe the several instances of one-on-one dialogue between a teacher and a student while working, presenting, or reviewing a design project. A design conversation adopts a particular language that we call the language of design or design language (the fundamentals of which have been laid out by Schön [1983, 1985]). Design language is an expression of the design process, that is, it communicates aspects of designing as it unfolds; since learning how to design is the central objective of design education it follows that by analysing the language we should uncover (part of) the educational process.

The research firstly describes the educational context that frames the conversations between teacher and student. Secondly, the research centres on the observation and analysis of conversations between teacher and student in real-context design studios. At this stage, we adopt design language as the primary analysis framework.

Research questions

The research questions that guide this thesis are exploratory and descriptive and serve mainly as guidelines for the empirical studies. The questions are: (1) *What is the result of design conversations?* In which we aim to discover if design conversations reveal new knowledge and what impact it has on the student's design process and project; (2) *What is the role of design language in design conversations?* A question that centres on finding to what extent does an analysis of the language of design makes the design process of teacher and student more explicit and also focusses on the differences in discourse between the pair; and finally, (3) *How do the defining features of the design studio influence the dialogue between*

teacher and student?

These questions align with the research objectives; namely, in that we aim to develop a model of the design studio setting that accurately describes its defining features regarding how they influence the teacher and student interaction. Also we intend to make the content of teacher-student interactions more explicit; compare how teachers and students use the language of design during design conversations and identify the critical differences between them; propose a taxonomy of teacher and student interactions in the design studio; critically analyse the current terminology on this subject and contribute to more stable definitions; and finally identify key aspects to explore in future research, with an emphasis on the development of guidelines for the teaching practice of design teachers.

Description of studies and methods used

The research methodology answers the following conditions: It is clear that the current understanding of teacher-student interaction in a design studio setting is incomplete, particularly, the knowledge that emerges from real-context observations is still lacking. Thus, the object of study requires mapping out, clarification of terminology, and critical analysis of existing taxonomies.

These circumstances call for exploratory research with a predominance of qualitative methods, which we combined with a descriptive methodology. The purpose of descriptive research is to make careful observations and develop detailed documentation of a phenomenon. Descriptive research seems appropriate for an object of study that has been broadly defined but seldom analysed in empirical observations.

Case studies

The empirical support of the thesis comes from four case studies that present an in-depth analysis of design education in practice. Each case study details the real-context observation and analysis of a pair of participants (one teacher and one student), ranging from first-year undergraduates to master students.

The methods used to conduct the case studies are divided into three phases: (1) data collection, (2) database development, and (3) database analysis.

The first phase concerns the observation and audio-recording of design studio classes, complemented by note-taking, and photographs of the sketches, drawings, or models that were part of the interactions. During this stage the studio sessions were recorded in its entirety, that is, we

did not select a teacher–student pair a priori; instead, we identified the conversations that had more potential for analysis (longer and uninterrupted conversations between teacher and student, or a sequence of short interactions between the same student and the teacher) after the session was completed.

The second phase concerned the creation of a database for analysis. This stage is crucial to convert raw data into a format that facilitates analysis. The database was created in three sequential activities: (1) transcribing (2) translating and (3) analysis table. First, the research team transcribed the audio-recordings, a task followed by the translation of the transcripts from Portuguese to English. Next, we inserted the transcripts into a table that registers the teacher–student interaction from beginning to end. The table is divided according to the basic unit of analysis, which is the verbalisation (an uninterrupted sequence of speech). Besides the series of verbalisations, the table also included data such as timestamps, pseudonyms, word count, notes, and a column for coding the protocols.

Finally, the third phase – data analysis – is the determining part of the research; all insights result from the work done at this stage. The analysis uses conversation analysis combined with grounded theory procedures. Grounded theory is preferably used when there are no existing theories or only incomplete theories about the object of study, that is when the current set of theories do not describe a setting accurately. Instead of developing another theory by deduction, with the grounded theory method we can generate theory by induction because the theory emerges from the empirical analysis of the phenomenon under study. Grounded theory emphasises the discovery of insights in the data being analysed rather than on the verification of theories established a priori by logical deduction.

Case study 1 Grace & Dylan

The first case study focusses on the interactions of one student (Dylan) and his studio teacher (Grace). Dylan's project concerned the design of a subway station. The case study lasted several hours, during which the pair had several brief encounters. The conversations developed around the student's three-dimensional model of the station.

The main finding of this study was that the student did not (with one isolated exception) verbally reflect on his design process, while the teacher often stopped to consider how the design was evolving and how the student was designing. Also, the teacher also offered lengthy explanations about designing in general. Furthermore, even in more practical matters there was an essential difference between the speeches

of the student and the teacher: the teacher consistently tried to make connections across design domains while keeping a broad perspective of the whole project, whereas the student tended to focus on one area at the time often losing track of how it related to the larger whole.

Case study 2

Ella & Janis

In this case study, we followed Ella (teacher) and Janis (student) during a studio session of a first-year design course. The briefing combined two-dimensional and three-dimensional design; the purpose is to explore modules as the generating elements of form (in both two and three dimensions). During the project, the students learn to create geometric matrixes based on a single two-dimensional module as well as three-dimensional structures supported by the repetition of a single three-dimensional module.

This case study reinforced the finding that there are substantial differences in the propensity to verbally express reflection on the design process between teacher and student. During the design conversation reported in this case study, the teacher frequently punctuated her speech with examinations of design moves and evaluations of the current state of the project. The student, on the contrary, did not express the same level of reflection on her process, even though the teacher insisted that she elaborated on her decision-making criteria and demonstrated an ability to evaluate her work and process.

Another finding was that direct manipulation of three-dimensional models correlates (we observed it during case study 1 as well) with a more practical discourse by both teacher and student. The case study also suggested that an eagerness to engage in dialogue, on the part of the student, has a positive impact on how the project evolves since we observe the student's initial conceptions of the design situation changed, the process became unstable culminating with the rise of alternative solutions for the design.

Case study 3

Albert & Paul

This case study was conducted in the context of a masters design course in which the students had to design a system of public transport (specifically a tram line) and challenged to consider the entire context and complexity of public transportation. The conversation between studio tutor Albert and student Paul is longer than the previous case studies.

The case again shows how there is a marked difference between the teacher's tendency to verbally reflect on his process and the (almost total)

absence of similar manifestations on the part of the student. Furthermore, the case had the particularity of the teacher often drawing to illustrate his explanations.

Given the lack of verbal articulation of the design process on the part of Paul, we observed how the teacher often examined the student's drawings to try to disclose threads of the student's design process. From this study emerged the notion of sketching as a laboratory to explore ideas. That is, the sketches (and sketching) can have the role of being a virtual space shared by teacher and student to explore ideas, test their feasibility, and examine potential solutions.

Finally, we observed that the student often reached dead-ends, that is, moments of hesitation when he was unable to continue to elaborate on ideas or partial solutions and fell silent. This was particularly the case when the student focussed excessively on details without linking them to the overall design.

Case study 4 Robert & Patti

This case study was conducted in the same course as the previous one, but with a different teacher and student. The conversation between Robert (teacher) and Patti (student) is also longer than the first couple of case studies.

In the case of Patti, we again observe a student that, following her graduate and undergraduate colleagues, does not articulate her reflection on the design process during the conversation with her teacher. Also, the student had difficulties linking the different elements of her design; for Patti, partial solutions and problems are mostly considered in isolation. We observed how this approach to the design process limited her ability to come up with sufficient alternative ideas for her project.

Design thinking research symposium study

This study complements the four case studies. The study was conducted during our participation in the 10th Design Thinking Research Symposium (DTRS10). When compared with the case studies the main difference is that the DTRS study was based on a database of video recordings and transcripts of seven students enrolled in the third-year of an undergraduate industrial design course. The briefing concerns the design of a casual seating solution for an office space.

During the symposium, there were several rounds of feedback and interaction between researchers. The successive tiers of feedback received were fundamental for the maturing of the theoretical framework

of the thesis. Furthermore, one of the themes that emerged from the symposium was how to communicate data, results, and analysis in a visual form; this is one of the central issues explored with this study, in that we employed an analysis framework that uses visual diagrams to both communicate and analyse the data.

The results of the study reinforce the idea that design language is a common language underpinning the teacher and students dialogue. Furthermore, from our analysis, it is clear that the teacher is more fluent in design language than the student. More importantly, the teacher consistently exhibited a broader range of connections between design domains in his discourse, that is, he often elaborated on how different aspects of a design relate with each other and contribute to the structuring of a coherent whole.

On the other hand, our analysis shows that the students employ a more fragmented approach, focussing on specific areas and drawing fewer links between categories. Another insight was that there was a difference between the sessions mediated by sketches and the sessions mediated by other types of visual representations such as physical or computer-generated models. The sketch-mediated sessions were significantly more productive in design language usage. This insight points to the study of sketching as a useful medium to establish effective communication between teacher and student.

The visual methods used were effective in capturing the content of these interactions and render it in a visual display. The resulting patterns synthesised and communicated a significant amount of interconnected data that would be otherwise more challenging to grasp.

Conclusions

Both novice and graduate design students do not tend to verbally express their reflections on the design process. Teachers should be aware of this pattern and concentrate on understanding if this is due to lack of self-reflection on the students or an inability to verbally express it. Our recommendation is for teachers to encourage students to practice self-reflection *during* – instead of after the fact – the conversations in the studio.

Considering the difficulty that students reveal in expressing their (design) thinking, teachers should consider adapting the interaction according to the particularities of each student. It may be interesting to search for ways of encouraging students to illustrate their design process. Some students may reveal aspects of their process mostly in their drawings, sketches, and through physical and virtual models; while others may be comfortable when engaging in dialogue. Also, teachers could seek ways

to make the students participate in the discussion so that they may contribute with their input.

Studio teachers should lead the students to make connections between thinking and actions, but teachers should also practice their self-awareness regarding the types of discourse (meta-design discourse and design grammar) used in the studio.

Since time is a valuable resource, it is worth managing studio time to get the most out of the individual meetings with the students. As such, more meetings should take place shortly after the project began and the student has completed preliminary work, explored ideas, but has not yet settled on any definitive directions for the project.

Finally, from our studies, we observed that the design studio is a setting where the usually tacit knowledge about design is made explicit (mostly by the teacher), as such, the studio has the potential to be a place to connect research, education, and practice of design. Thus, design conversations can be a situation where the strands of design research, education, and practice can converge, enhancing the relationships between this often separated areas of design knowledge.

Samenvatting

Het doel van dit proefschrift is om het proces van onderwijzen en leren ('teaching and learning') in design te beschrijven. Systematische kennis over ontwerp- en onderwijs ontbrak tot nu toe in empirische studies. Als zodanig is het proefschrift opgebouwd uit vier casestudy's op basis van een in een realistische setting. De casestudy's bestaan uit directe observaties en analyse van vier verschillende typen interacties tussen docent en student, onder wie zowel Bachelor- als Masterstudenten. Een observatiestudie van negen gesprekken tussen docenten en studenten, via een videodatabase, vormt een aanvulling op de bevindingen van de casestudy's.

Het format voor onderwijzen in en leren hoe te ontwerpen is een dialoog die plaatsvindt in een ontwerpstudio. Er is uitwisseling tussen docent en student, terwijl zij zich beiden concentreren op een ontwerpproject. Dit is de typische situatie in de ontwerpstudio, een praktische educatieve omgeving waar studenten leren door te doen ('learning by doing'), dat wil zeggen door te ontwerpen onder de supervisie van een ontwerpdocent.

De titel van het proefschrift – *Design Conversations* – is de term die we voorstellen om de verschillende voorbeelden van de een-op-een dialoog tussen docent en student te beschrijven tijdens het werken aan en het presenteren of beoordelen van een ontwerpproject. Een ontwerpgesprek neemt een bepaalde taal aan die we de taal van het ontwerp of de *Ontwerptaal* ('Design Language') noemen (de grondbeginselen daarvan zijn uiteengezet door Schön [1983, 1985]). Ontwerptaal is een expressie van het ontwerpproces, dat wil zeggen ze communiceert aspecten van het zich ontvouwende ontwerpen. Aangezien leren ontwerpen de centrale doelstelling van het ontwerp- en onderwijs is, volgt hieruit dat we door het analyseren van de taal (een deel van) het onderwijsproces moeten ontdekken.

Het onderzoek beschrijft in de eerste plaats de onderwijscontext die de gesprekken tussen docent en student omlijst. Ten tweede concentreert het onderzoek zich op de observatie en de analyse van gesprekken tussen docent en student in de reële context van de ontwerpstudio. In dit stadium gebruiken we ontwerptaal als primair analysekader.

Onderzoeksvragen

De onderzoeksvragen die leidend zijn voor dit proefschrift, zijn exploratief en beschrijvend van aard en dienen hoofdzakelijk als richtlijnen voor de empirische studies. De vragen zijn: (1) *Wat is het resultaat van ontwerp- en gesprekken?* Waarin we willen ontdekken of ontwerp- en gesprekken nieuwe kennis onthullen en welke impact dit heeft op het ontwerp- en het project van de student; (2) *Wat is de rol van ontwerptaal in ontwerp- en gesprekken?* Een vraag die zich richt op het nagaan van in hoeverre een analyse van de ontwerptaal het ontwerp- en het proces van docent

en student meer expliciet maakt en daarnaast focust op de verschillen in discours tussen de twee; en tenslotte (3) *Hoe beïnvloeden de bepalende kenmerken van de ontwerpstudio de dialoog tussen docent en student?*

Deze vragen komen voort uit de onderzoeksdoelstellingen, in die zin dat we een model van de ontwerpstudio-setting willen ontwikkelen die nauwkeurig beschrijft hoe en welke bepalende kenmerken de interactie tussen docent en student beïnvloeden. Ook is het onderzoek gericht op de volgende aspecten:

(i) de inhoud van de interacties tussen docent en student meer expliciet maken; (ii) vergelijken hoe docenten en studenten de ontwerptaal gebruiken tijdens ontwerpgesprekken en de kritische verschillen tussen hen identificeren; (iii) een taxonomie voorstellen van interacties tussen docent en student in de ontwerpstudio; (iv) de huidige terminologie over dit onderwerp kritisch analyseren en bijdragen aan stabielere definities; en uiteindelijk (v) belangrijke aspecten identificeren voor toekomstig onderzoek, met de nadruk op de ontwikkeling van richtlijnen voor de leerpraktijk van ontwerpdocenten.

Beschrijving van studies en gebruikte methoden

De onderzoeksmethode komt tegemoet aan de volgende omstandigheden: Het is duidelijk dat het huidig inzicht in de interactie tussen docent en student in een ontwerpstudio onvolledig is. Met name kennis die voortkomt uit waarnemingen in de reële onderwijssituatie ontbreekt nog steeds. Het object van studie vereist dus het in kaart brengen van bestaande taxonomieën, ze kritische analyseren het verduidelijken van terminologie.

Deze omstandigheden vragen om exploratief onderzoek met voornamelijk kwalitatieve methoden die we combineerden met een beschrijvende methodologie. Het doel van beschrijvend onderzoek is om nauwkeurige observaties te maken en gedetailleerde documentatie van een fenomeen te ontwikkelen. Ze lijkt daarom geschikt voor een object van onderzoek dat breed is gedefinieerd maar zelden is geanalyseerd door middel van empirische waarnemingen.

Casestudy's

De empirische ondersteuning van het proefschrift is afkomstig van vier casestudy's die een diepgaande analyse van ontwerponderwijs in de praktijk presenteren. Elke casestudy beschrijft in een realistische context de observatie en analyse van de gesprekken van een tweetal deelnemers (een docent en een student). De student varieert van eerstejaars Bachelor tot Master.

De methoden die werden gebruikt om de casestudy's uit te voeren, zijn verdeeld in drie fasen: (1) gegevensverzameling, (2) database-ontwikkeling en (3) database-analyse.

De eerste fase betrof de observatie en audio-opnames van studioklassen,

aangevuld met notities, foto's van schetsen, tekeningen of modellen die deel uitmaakten van de interacties. Tijdens deze fase werden de studiosessies in zijn geheel op video opgenomen, dat wil zeggen zonder a priori een docent-student tweetal te selecteren. In plaats daarvan selecteerden we, nadat de sessie was voltooid, die gesprekken die meer potentieel voor analyse hadden (langere en ononderbroken gesprekken tussen docent en student, of een reeks korte interacties tussen dezelfde student en de docent).

De tweede fase betrof het creëren van een database voor analyse. Deze fase was cruciaal om onbewerkte gegevens om te zetten in een indeling die analyse vergemakkelijkt. De database werd gecreëerd in drie opeenvolgende activiteiten: (1) transcriptie, (2) vertaling en (3) vervaardiging van een analysetabel. Het onderzoeksteam begon met het maken van transcripties van de audio-opnames, een taak gevolgd door de vertaling van de transcripties van het Portugees naar het Engels. Vervolgens werden de transcripten ingevoegd in een tabel die de interactie tussen docent en leerling van begin tot eind registreert. De tabel is ingedeeld volgens de basiseenheid van analyse, het verwoorden (een ononderbroken reeks van spraak). Naast de reeks verbale uitingen bevatte de tabel ook gegevens als tijdstip, pseudoniemen, woordentelling, opmerkingen en een kolom voor het coderen van de gespreksprotocollen.

Ten slotte, de derde fase - data-analyse - was het bepalende deel van het onderzoek; alle inzichten komen voort uit het werk dat in dit stadium is gedaan. De analyse maakte gebruik van protocolanalyse in combinatie met 'grounded theory' procedures.

Grounded theory wordt bij voorkeur gebruikt wanneer er geen bestaande theorieën zijn of alleen onvolledige theorieën over het object van studie, d.w.z. wanneer de huidige theorieën een object van studie niet nauwkeurig beschrijven. In plaats van een andere theorie te ontwikkelen door middel van deductie, kunnen we met deze methode theorie genereren door inductie, omdat de theorie voortkomt uit de empirische analyse van het fenomeen in studie. *Grounded theory* benadrukt de ontdekking van inzichten in de geanalyseerde gegevens in plaats van de verificatie van theorieën die a priori door logische deductie zijn vastgesteld.

Casestudy 1 Grace & Dylan

De eerste casestudy richt zich op de interacties van een student (Dylan) en zijn studio-docent (Grace). Het project van Dylan betrof het ontwerpen van een metrostation. De casestudy duurde enkele uren, tijdens welke het tweetal verschillende korte ontmoetingen had. De gesprekken ontwikkelden zich rond het driedimensionale (3-D) model dat de student van het station had gemaakt.

De belangrijkste bevinding van deze studie was dat de student, op een enkele uitzondering na, niet verbaal reflecteerde over zijn ontwerpproces, terwijl de docent vaak stilstond om na te gaan hoe het ontwerp

evolueerde en hoe de student aan het ontwerpen was. Ook bood de docent uitgebreide uitleg over ontwerpen in het algemeen. Bovendien was er, zelfs in meer praktische zaken, een essentieel verschil tussen de bewoordingen van de student en de docent: de docent probeerde consequent verbindingen te leggen tussen ontwerpdomeinen terwijl hij een breed perspectief hield op het hele project, terwijl de student zich meestal op één enkel gebied per tijdseenheid concentreerde en vaak het verband met het grotere geheel uit het oog verloor.

Casestudy 2 Ella & Janis

In deze casestudy volgden we Ella (docent) en Janis (student) tijdens een studio-sessie van een eerstejaars ontwerp opdracht. De briefing combineerde 2-D en 3-D ontwerp. Tijdens het project leren de studenten geometrische matrices creëren op basis van een enkele tweedimensionale module, evenals driedimensionale structuren die worden ondersteund door de herhaling van een enkele driedimensionale module. Het doel was om modules te verkennen als de generatieve elementen van vorm (in zowel twee als drie dimensies).

Deze casestudy versterkte de bevinding dat er tussen docent en student, substantiële verschillen zijn in de neiging tot mondelinge reflectie op het ontwerpproces. Tijdens het ontwerp gesprek dat in deze casestudy wordt gerapporteerd, doorspekte de docent herhaaldelijk haar gesprek met vragen aan de student naar mogelijke vervolgzetten en naar evaluaties van de huidige staat van het project. De student bracht daarentegen niet hetzelfde niveau van reflectie op haar proces tot uiting, zelfs ondanks het feit dat de docent erop stond dat de student haar besluitvormingscriteria nader toelichtte en uitwerkte, en haar kunnen liet zien in het evalueren van haar ontwerpwerk en het proces.

Een andere bevinding was dat directe manipulatie van driedimensionale modellen, als onderdeel van de interactie, correleerde met een meer praktisch discours van zowel docent als student (we observeerden het ook tijdens casestudy 1). De casestudy suggereerde ook dat hoe groter het enthousiasme bij de student om de dialoog aan te gaan, des te positiever het effect op hoe het project evolueert. We konden zien dat, zodra de oorspronkelijke idee van de student over de ontwerpsituatie veranderde, het proces instabiel werd culminerend in het genereren van alternatieve oplossingen voor het ontwerp.

Case study 3 Albert & Paul

Deze casestudy werd uitgevoerd in het kader van een Master design course, waarbij de studenten een systeem van openbaar vervoer moesten ontwerpen (vooral gericht op een tramlijn). Zij werden uitgedaagd om de volledige context en complexiteit van het openbaar vervoer in overweging te nemen. Het gesprek tussen studio-tutor Albert en student Paul is

langer dan de vorige case-studies.

De case laat opnieuw zien hoe er een duidelijk verschil is tussen de neiging van de docent om verbaal over het proces van de student na te denken en de (bijna totale) afwezigheid van soortgelijke manifestaties van de kant van de student. Bovendien had de case als bijzonderheid dat de docent vaak tekende om zijn uitleg te illustreren.

Gezien het gebrek aan verbale articulatie van het ontwerpproces door student Paul, probeerde de docent de tekeningen van de student te analyseren teneinde discussiepunten in het ontwerpproces van de student te onthullen.

Uit deze studie ontstond het idee om schetsen op te vatten als een *laboratorium voor ideeënverkenning*. Dat wil zeggen, de schets (en het schetsen) kan de rol aannemen van een virtuele ruimte die docent en student delen om ideeën te verkennen, hun haalbaarheid te testen en mogelijke oplossingen te onderzoeken.

Ten slotte constateerden we dat de student vaak last heeft van een *designer's block*, dat wil zeggen momenten van aarzeling, niet in staat om door te gaan met het uitwerken van ideeën of gedeeltelijke oplossingen waarna de student stil valt. Dit was met name het geval wanneer de student zich te veel op details concentreerde zonder ze aan het totale ontwerp te koppelen.

Casestudy 4 Robert & Patti

Deze casestudy werd uitgevoerd in dezelfde cursus als de vorige, maar met een andere docent en student. Het gesprek tussen Robert (docent) en Patti (student) is ook langer dan de eerste paar casestudy's.

In het geval van Patti observeerden we opnieuw een student die net als Bachelor- en Mastercollega's, moeite heeft om in een gesprek met de docent in woorden te reflecteren over haar ontwerpproces. Ook had de student moeite om de verschillende elementen van haar ontwerp met elkaar in verband te brengen.

Voor Patti worden gedeeltelijke oplossingen en problemen meestal afzonderlijk beschouwd. We observeerden hoe deze benadering van het ontwerpproces haar vermogen beperkte om voldoende alternatieve ideeën voor haar project te bedenken.

Study for design thinking research symposium (dtrs10)

Deze studie vormt een aanvulling op de vier casestudy's. De studie werd uitgevoerd tijdens onze deelname aan het 10e *Design Thinking Research Symposium (DTRS10)*. In vergelijking met de casestudy's is het belangrijkste verschil dat de DTRS-studie was gebaseerd op een database met video-opnamen en transcripties van zeven studenten die deelnamen aan een derdejaars 'undergraduate industrial design course'. De briefing betreft het ontwerp van een informele zitoplossing voor een

kantoorruimte.

Tijdens het symposium waren er verschillende rondes van feedback en interactie tussen onderzoekers. De opeenvolgende niveaus van ontvangen feedback waren van fundamenteel belang voor het rijpen van het theoretische raamwerk van het proefschrift. Bovendien was een van de thema's die uit het symposium naar voren kwamen: hoe data, resultaten en analyses in een visuele vorm te communiceren? Dit was een van de centrale kwesties die in onze studie werden onderzocht, namelijk hoe een analysekader te creëren dat visuele diagrammen gebruikt om zowel de gegevens te communiceren als te analyseren.

De resultaten van de studie versterken het idee dat ontwerptaal een gemeenschappelijke taal is die de dialoog tussen docent en studenten ondersteunt. Bovendien blijkt uit onze analyse dat de docent vloeiender in ontwerptaal is dan de student. En nog belangrijker, de docent liet in zijn betoog consequent een breder scala aan verbanden zien tussen ontwerpdomeneinen. Dat wil zeggen, hij wijdde vaak uit over hoe verschillende aspecten van een ontwerp zich tot elkaar verhouden en bijdragen aan de structurering van een samenhangend geheel.

Aan de andere kant laat onze analyse zien dat studenten een meer gefragmenteerde aanpak hanteren, met specifieke aandachtspunten en minder koppelingen tussen categorieën. We kwamen ook tot het inzicht dat er een verschil is tussen studio-sessies met schetsen als hulpmiddel en de sessies waarin andere soorten visuele representaties worden gebruikt, zoals fysieke of computer-gegenereerde modellen. De op schets gebaseerde sessies waren aanzienlijk productiever in het gebruik van ontwerptaal. Dit inzicht geeft aan dat schetsen een nuttig medium is om effectieve communicatie tussen docent en student tot stand te brengen.

De gebruikte visuele methoden waren effectief in het vastleggen van de inhoud van deze interacties en in het weergeven in een visueel display. De resulterende patronen coördineerden en communiceerden een significante hoeveelheid onderling verbonden gegevens die anders moeilijker te begrijpen zouden zijn.

Conclusies

Of je nu beginnende Bachelor studenten neemt of bijna afgestudeerde Masterstudenten, beiden hebben niet de neiging om hun reflecties over het ontwerpproces mondeling uit te drukken. Docenten moeten zich bewust zijn van dit patroon en zich bezighouden met de vraag of dit te wijten is aan een gebrek aan zelfreflectie van de studenten of aan een onvermogen om het mondeling uit te drukken. Onze aanbeveling is dat docenten studenten aanmoedigen om zelfreflectie te oefenen tijdens - in plaats van achteraf - de gesprekken in de studio.

Gezien de problemen die studenten hebben met het uiten van hun (ontwerp) denken, moeten docenten overwegen om de interactie aan te passen aan de specifieke eigenschappen van elke student. Het kan

interessant zijn om te zoeken naar manieren om studenten aan te moedigen hun ontwerpproces te illustreren. Sommige studenten kunnen aspecten van hun proces meestal in hun tekeningen, schetsen en fysieke en virtuele modellen laten zien. Anderen voelen zich misschien op hun gemak als ze een dialoog aangaan. Docenten zouden ook manieren kunnen vinden om studenten aan de discussie te laten deelnemen, zodat ze met hun inbreng kunnen bijdragen aan de dialoog.

Studiodocenten hebben de taak de studenten aan te sturen in het leggen van verbanden tussen denken en doen. Tegelijkertijd zouden ze zich telkens bewust rekenschap moeten geven van het type discours (meta-design discours en ontwerpgrammatica) dat ze in de studio gebruiken en zich daar in systematisch trainen.

Omdat tijd een waardevolle hulpbron is, is het de moeite waard voor de docent om controle te houden op studiotijd om daarmee het maximale uit de individuele ontmoetingen met de studenten te halen. Als zodanig moeten bijeenkomsten in het begin frequenter plaatsvinden, kort nadat het project is begonnen en de student zijn voorbereidende werkzaamheden heeft voltooid, ideeën heeft onderzocht, maar nog geen definitieve aanwijzingen voor het project heeft gevonden.

Ten slotte hebben we op basis van onze studies kunnen vaststellen, dat de ontwerpstudio een omgeving is waar de meestal impliciete kennis ('tacit knowledge') over ontwerpen expliciet wordt gemaakt (meestal door de docent). Als zodanig heeft de studio de potentie om een plek te zijn waar onderzoek, onderwijs en ontwerppraktijk samenvallen. Ontwerpgesprekken kunnen dus een situatie creëren waarin onderdelen van ontwerponderzoek, -onderwijs en -praktijk convergeren, waardoor de banden tussen deze vaak van elkaar gescheiden gebieden worden aangehaald.

Annexes

Annex 1 – Full transcripts of case study 1

Case Study 1 Grace & Dylan

Design conversation 1.1

Teacher/ Student	Transcript
Grace	<i>Had you seen this book before?</i>
Dylan	<i>No, I didn't even knew about it...</i>
Teacher	<i>It's very important that you have this information.</i>
Student	<i>I had no idea...</i>
Teacher	<i>It has trains. It was our base last year...</i>
Student	<i>Exactly.</i>
Teacher	<i>This is the rails...maybe you should use the dimension of these...just the basic dimension, so that you have a volume.</i>
Student	<i>Yes perhaps that's what... yes, that's it... because I couldn't even find this. I couldn't find this information... I wasn't sure I wanted to work that merely as a cube and this way maybe I can move one of the facets...erm...and regarding...and regarding...</i>
Teacher	<i>Is there anything left from last year?</i>
Student	<i>I don't think so...</i>
Teacher	<i>Well let me see... in last year's folder – let me also ask the other teacher if she has... because last year we found a website which was exclusively about trains... it had all the measurements...</i>
Student	<i>Because you know... what I found in the internet, the ratio between a regular train and a subway is very similar concerning the height... the only difference is really the length...</i>
Teacher	<i>Hum hum.</i>
Student	<i>And it also varies from subway to subway... they develop the subway lines in such a way... there are several systems... for example, in high demand lines in certain cities... they make it circular, and normally the carriages are smaller.</i>
Teacher	<i>Ah, okay, there's an optimization...</i>
Student	<i>Exactly.</i>
Teacher	<i>...according to the shape of the line.</i>
Student	<i>The ratio of the subway varies a lot according to the relation of the line.</i>
Teacher	<i>Maybe it is a bit irrelevant if you find the answer to that question or not.</i>
Student	<i>Yes that's it, that's it... so I think the question of the length, so... it would be more the dimension of the whole train...and not the carriage...</i>
Teacher	<i>Then, you should try it... and keep working on... and keep working already on your cube and the space...</i>
Student	<i>That's it... that's it.</i>

Case Study 1 Grace & Dylan

Design conversation 1.2

Teacher/ Student	Transcript
Dylan	<i>Teacher, it's going to be more or less like this.</i>
Grace	<i>Mm-hmm</i>
Student	<i>With a... with a...</i>
Teacher	<i>With vertical facets?</i>
Student	<i>Yes, yes!</i>

Case Study 1 Grace & Dylan

Design conversation 1.3

Teacher/ Student	Transcript
Grace	<i>Work from a top-view perspective.</i>
Dylan	<i>Okay.</i>

Case Study 1 Grace & Dylan

Design conversation 1.4

Teacher/ Student	Transcript
Grace	<i>That's good, because that's where your intervention space is.</i>
Dylan	<i>Yes... that's it!</i>

Case Study 1 Grace & Dylan

Design conversation 1.5

Teacher/ Student	Transcript
Grace	<i>Don't forget to place the cardboard on the side...</i>
Dylan	<i>Yes... yes...</i>
Teacher	<i>Because it's completely different to see the carriage above the horizontal plane.</i>
Student	<i>Exactly.</i>

Case Study 1 Grace & Dylan

Design conversation 1.5

Teacher/ Student	Transcript
Grace	<i>Don't forget to place the cardboard on the side...</i>
Dylan	<i>Yes... yes...</i>
Teacher	<i>Because it's completely different to see the carriage above the horizontal plane.</i>
Student	<i>Exactly.</i>

Case Study 1 Grace & Dylan

Design conversation 1.6

Teacher/ Student	Transcript
Grace	<i>So, here you can get more depth...</i>
Dylan	<i>Right.</i>
Teacher	<i>...a certain height which allows you to have more space to experiment more things... do you understand what I am telling you?</i>
Student	<i>Ah! So it doesn't end here?</i>
Teacher	<i>This point...</i>
Student	<i>Hum hum</i>
Teacher	<i>...this edge...</i>
Student	<i>Hum hum</i>
Teacher	<i>connects with the height of this plane...</i>
Student	<i>Hum hum</i>
Teacher	<i>Everything goes up...</i>
Student	<i>Ah, okay...</i>
Teacher	<i>and you support this here. Which means you get this extra space here...</i>
Student	<i>Exactly!</i>
Teacher	<i>...in order for this to go to the ground...</i>
Student	<i>Ah okay, now I get it...</i>
Teacher	<i>...you build there... as if it was the pit</i>
Student	<i>Exactly.</i>
Teacher	<i>...of the rails right?</i>

Case Study 1 Grace & Dylan

Design conversation 1.6

Teacher/ Student	Transcript
Student	<i>Exactly. Okay. Okay.</i>
Teacher	<i>But now you'll need to cut more cardboard.</i>
Student	<i>I have more cardboard... And then okay, I was thinking of cutting an opening here. Erhm... and then build a cone... to help with...</i>
Teacher	<i>To help you control the lighting?</i>
Student	<i>yes, so that the lighting is not very expansive... so as if it was an intermittent lighting with the sole purpose of pointing out the... the front of the train</i>
Teacher	<i>It softens that area..</i>
Student	<i>yes, if the light is too intense...</i>
Teacher	<i>you need the cone to soften the... light beam.</i>
Student	<i>yes... so, I can use external things like the cone...</i>
Teacher	<i>yes you can, of course you can! It works just like the opening you did here.</i>
Student	<i>Exactly</i>

Case Study 1 Grace & Dylan

Design conversation 1.7

Teacher/ Student	Transcript
Dylan	<i>This is how I'm gonna position the...</i>
Grace	<i>You cross it here...</i>
Student	<i>Yes. And then I'm going to fill it all the way down –</i>
Teacher	<i>But then you won't explore this space here...</i>
Student	<i>But I thought I would do... sort of apply even if it's later... another box in front of it just so that this doesn't get any lower... since I have all this space.</i>
Teacher	<i>Yes, yes... You can even explore... yes, it's more interesting for your exploration because you end up having the same height...</i>
Student	<i>Exactly that's it. And then this whole section becomes more interesting...</i>
Teacher	<i>Mm-hmm</i>

Case Study 1 Grace & Dylan

Design conversation 1.8

Teacher/ Student	Transcript
Grace	<i>Imagine that the light... that you go beyond the reality that it's represented totally here right?</i>
Dylan	<i>...let's imagine that this cube is completely red inside.</i>
Teacher	<i>For instance yes.</i>
Student	<i>And it's as if a line would go trough... that is... if I could represent in this format – if the tunnel was a completely red line.</i>
Teacher	<i>Ah yes. In backlight.</i>
Student	<i>Exactly, that's it.</i>
Teacher	<i>But what I am suggesting is: what you have here is the model of a real situation right? So, you take advantage of your model and... let's imagine that your project was to manipulate lighting in order to completely change the subway station. You take advantage of your model to show it. You manipulate the light and colour to change the whole atmosphere of the space.</i>
Student	<i>I hadn't thought of that... I was thinking of representing the subway when it had halted.</i>
Teacher	<i>This is the moment when it stops. It's the subway's moment of being still. You're representing the subway as if it was in the terminal...</i>
Student	<i>So, in order to represent those lighting transformations it would be better to represent the hangar, or not?</i>
Teacher	<i>The whole platform? Maybe... you have to think about what you want to do... but imagine that you also had to intervene in the tunnel... for example, have you noticed the new pt-blue station in Lisbon? . Have you noticed, they seized the station using only light and colour. Every time the subway enters the station it turns blue... so, imagine that you were going to intervene in the tunnel using only light and colour... perhaps the lights turns on in specific moments...</i>
Student	<i>Yes, yes, yes...</i>
Teacher	<i>It seems to me that you are too focussed in representing reality, which is also important because you end up learning to control a series of tools... but add to that an explorative side...</i>
Student	<i>okay... if I had this cube as a basis... then it could be just a matter of filling the tunnel inside with another colour... that is... the light-beam itself would reinforce the colour of the tunnel</i>
Teacher	<i>Okay... I don't know...</i>
Student	<i>Let's say, the tunnel itself would reflect the light...</i>
Teacher	<i>It's possible.</i>
Student	<i>Those situations when the subway lightens the whole tunnel all around... as if the tunnel would reflect the light... could be interesting... I was thinking, can I represent movement?</i>
Teacher	<i>That's exactly what I was going to tell you next... here you almost need some movement, to add a bit more –</i>

Case Study 1 Grace & Dylan

Design conversation 1.8

Student	<i>But then... for example... if I had no movement... lets imagine that... like in the movies... if a camera is fixed on the train... the camera is stopped, the metro is stopped... the only thing that moves is the space itself... I could do that just with the space through the light projection. The light approaches... the tunnel gets progressively more lighten, for example...</i>
Teacher	<i>Yes, a sort of animation. But we have to... you don't have much time right?</i>
Student	<i>Right. And now that is bothering me a bit. But okay.</i>
Teacher	<i>But that is also why this project is important. You have to learn to manage your reaction time and learn how to do something very important which is to balance our expectations. Because it happens all the time, you have thousands of ideas and you can see the final images, but then there is no time to execute them... the problem is not developing great skills but realise our limitations.</i>
Student	<i>Okay. Great! Thank you!</i>

Case Study 1 Grace & Dylan

Design conversation 1.9

Teacher/ Student	Transcript
Dylan	<i>What do you think?</i>
Grace	<i>Now you are going towards (giggles) an abstract kind of... but yes, but you can do it anyway! ...but do you understand what I mean? We are already...</i>
Student	<i>A bit far ahead?</i>
Teacher	<i>The next exercise in the project deals with the perception of space and bodies beyond the visual... maybe then... but do it anyway!</i>
Student	<i>I should do this experiment anyway?</i>
Teacher	<i>Yes, but be mindful of the conclusions you are going to derive from this experiment.</i>
Student	<i>I already... I can already see some... actually...</i>
Teacher	<i>That's the most important part.</i>

The teacher leaves the student at the desk and continues her round. 40 seconds elapse and the teacher returns to and finds the student who is paused in deep reflection while staring at the model.

Teacher	<i>So, you are completely lost?</i>
Student	<i>I'm thinking... I need to... the problem is time but...</i>
Teacher	<i>Just go on with the experiments you mentioned.</i>
Student	<i>Yes, yes.</i>

Case Study 1 Grace & Dylan

Design conversation 1.7

Teacher/ Student	Transcript
Dylan	<i>For instance, here in this perspective I transmit more the sense that there is a station here. There is more liveliness in this photo than the other. But that's it! I had to do this in order to reach this conclusion.</i>
Grace	<i>Of course, the light that you actually see is not completely white is it?</i>
Student	<i>Exactly. (...) here it's as if it represents a barrier, in the tunnel itself...</i>
Teacher	<i>Yes, you can do that. You can always insert a comment [meaning a caption in the image] explaining that.</i>
Student	<i>Exactly. It's a barrier... I think this image expresses that idea of a barrier... I also have films but I can't see it here... Ah! Because what I was about to do was: take out this wall and replace it with see through paper... and then light it from inside.</i>
Teacher	<i>okay.</i>

Annex 2 – Full transcripts of case study 2

Case Study 2 Ella & Janis

Design conversation 2.1

Janis	<i>I've done one like this, and another one like this... and I think this one is nicer. But now I've done so many, but they all seem the same!</i>
Ella	<i>How about... you'll have to select 6.</i>
Student	<i>Mm-hmm</i>
Teacher	<i>How about you spread them all around, and figure out what you want to do with all this work?</i>
Student	<i>Okay, I can do that.</i>
Teacher	<i>Maybe then they won't seem all the same anymore.</i>
Student	<i>Maybe.</i>
Teacher	<i>Maybe you'll be able to figure out some criteria for your selection. Maybe you'll become more pleased about the work...</i>
Student	<i>Yes...</i>
Teacher	<i>...and make a decision and move on. Deal?</i>
Student	<i>Deal.</i>
Teacher	<i>okay then, spread it!</i>
A few minutes later:	
Teacher	<i>Ah you really spread it! You acquired the competence of spreading. Good!</i>
Student	<i>So, this is one sign; over there it's the other one, and here we have a combination of both.</i>
Teacher	<i>Yes? okay then, how are we going to make a selection then?</i>
Student	<i>Okay</i>
Teacher	<i>Tell me.</i>
Student	<i>Some of them... well, first of all, I decided not to do anymore, because I think some of them if I just explore the negative version as well as changing the density they might be interesting. For example this one, or this one... now, some of them I am sure I really like. And others seem very plain, or very similar... I don't know...</i>
Teacher	<i>But is the criteria here just "I like/don't like"?</i>
Student	<i>No, it's also...</i>
Teacher	<i>So? What is your criteria then?</i>
Student	<i>Hmm...</i>
Teacher	<i>What is supposed... what does the briefing say?</i>
Student	<i>It's supposed to have –</i>
Teacher	<i>To summarize, it says you must chose 6 that are representative of your work; following notions such as order, contrast, rhythm. So. When we look at all this work, you either function by elimination or selection...</i>

Design Conversations: An exploratory study of teacher and student interaction.

Student	Exactly.
Teacher	<i>Or you can function by selection and elimination at the same time. By saying "this one I'm sure I want to keep, and this one I'm sure I don't." So, if you start doing that, surely you'll immediately select at least a few. And then some will remain to be selected... or eventually you'll realize there are still some explorations you need to do.</i>
Student	<i>For example, I think this one here, it shows contrast, it has some larger and smaller ones... and a certain order. Since it is more or less geometric. This one I also like the contrast...</i>
Teacher	<i>It doesn't have to be exactly like that (points to the briefing) it has to follow those criteria of course, but your selection must above all be representative of all your exploration, of your ideas, of the possibilities of surfaces that you explored. It has to tell a story through those 6 selections. Allowing that an outsider can understand that a surface can be explored in different ways. So, this one stays you say. What else?</i>
Student	<i>I also like this one. But I would also like to explore it further, whether with different densities or negatives.</i>
Teacher	<i>And then you have different degrees of complexity right? That's also a criteria, for instance there we understand there are many different geometric operations... but we can also start from step one; you must also consider if it makes sense to show the simplest surface as well. Because it marks the beginning...</i>
Student	<i>The surfaces must have a hierarchy between them?</i>
Teacher	<i>They should tell a story. If that's what you call a hierarchy...</i>
Student	<i>Yes, okay... (smiles) As if it was an evolution?</i>
Teacher	<i>Exactly, as if your making your line of thought visible. Even if you change it afterwards. You either make an intuitive "like/don't like" kind of selection, and then you begin to understand what underlies the "like/don't like", that actually there are other criteria that guided your choice... or you go the other way around, and you realise what distinguishes these surfaces and what should be selected or not. But what is essential is that you have the ability to make a decision, which is the most important decision in this exercise.</i>
Student	<i>Yes, I know.</i>

Case Study 2 Ella & Janis

Design conversation 2.2

Ella	<i>Ah, you're already working on your model –</i>
Janis	<i>Yes, okay, because I've already noticed that...well... I was considering which surface is better suited for...</i>
Teacher	<i>You don't have to use them as the floor-plan of your structure. It can or not be used like that... it can also be a side view...</i>
Student	<i>Yes...</i>
Teacher	<i>That is, the module has a certain 2 dimensional behaviour but it can, and probably is, quite different in 3d. Because it has that extra dimension.</i>
Student	<i>And also in terms of consistency.</i>
Teacher	<i>Yes. Don't forget that there is also the weight...</i>

Case Study 2 Ella & Janis

Design conversation 2.2

Student	<i>Exactly. For example I...in this case...well I already began working with cardboard in order to understand what is the easiest way to assemble the modules.</i>
Teacher	<i>Yes okay.</i>
Student	<i>erhm, but for example, with this one I thought I could use rotation; but with this one maybe... well, it has more points of contact.</i>
Teacher	<i>Yes, yes it has.</i>
Student	<i>So this one maybe I won't rotate it... I would simply built it straight. But for example if I use this one... both this one... or... yes, this one I would just built it straight up. Because if this is the floor-plan I think I can make it stable.</i>
Teacher	<i>It is not a bad starting point to consider that one of your surfaces can function as a floor-plan that generates the whole volume. But you can also release yourself from that idea, and just state that there is a 3 dimensional module that because it has that extra dimension it also acquires a new freedom and new possibilities. But also new constraints, namely regarding the constructive process.</i>
Student	<i>Yes (hesitates)</i>
Teacher	<i>With the 3 dimensions you have the problem of the constructive process and the fact that the structure must be self-supporting, it structures itself.</i>
Student	<i>Yes, yes. But for now, from what I have done, it would start with these two. Or this one as well.. with this one I like it that I could probably make it rotate.</i>
Teacher	<i>Notice that now you have 3 x 3 x 5. okay? So it's not this.</i>
Student	<i>Mm-hmm So it would be this?</i>
Teacher	<i>Exactly. And then 5.</i>
Student	<i>Mm-hmm So my idea would be –</i>
Teacher	<i>5 which is another... it's either that the structure is always straight...</i>
Student	<i>Yes, for example with this one I was thinking –</i>
Teacher	<i>But you don't have to do many. You only have to make one model.</i>
Student	<i>Yes..</i>
Teacher	<i>You can try many. But you only have to make one.</i>
Student	<i>Yes, yes. But these are just hypotheses for now. For example if I make this one I could use it as a floor-plan and then I rotate it upwards.</i>
Teacher	<i>Yes, you can do that. And it doesn't have to be consistent. You can rotate the first level and not the second and so on.</i>
Student	<i>Ah, so I could create blocks and then it is the blocks that rotate.</i>
Teacher	<i>Yes. In that space of 5 upwards and then 3 anything can happen.</i>
Student	<i>Mm-hmm, okay.</i>
Teacher	<i>Right? But you have to control more variables, the weight... the weight is highly relevant when you are thinking about a structure.</i>
Student	<i>Because the fact that there is this crossing between them...</i>

Case Study 2 Ella & Janis

Design conversation 2.2

Teacher	<i>Yes exactly, that's good thinking! The fact that it rotates or not has to do with the module itself and the weight distribution.</i>
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Student	<i>okay.</i>
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Annex 3 – Full transcripts of case study 3

Case study 3 Albert & Paul

Design conversation 3

Teacher/ Student	Transcript
Albert	<i>Paul, what about you, can I see your work?</i>
Paul	<i>So...I worked on maintenance, and cleaning, and the driver.</i>
Teacher	<i>Those large sheets are great.</i>
Student	<i>So, okay, concerning the maintenance there's a part here... right, that is... I have some doubts... I don't know a lot about parts... which parts have to be changed, which parts have to be accessible.</i>
Teacher	<i>From inside?</i>
Student	<i>From inside, yes. erhm... right, of course, maybe the electrical parts and the engine must be accessible. Okay, that's fine. But there's a certain unknown stuff that... otherwise...</i>
Teacher	<i>uh-hmm... I will use again the same approach I used back there which is the issue of the bus, because maybe it is easier for me. Later, you'll have to analyse where all the stuff is in the current tram. But in a city bus, typically, you have something like this: maybe I'll do it again here, you have the little wheels and it has a flooring that is flat in some areas and normally raised in others.</i>
Student	<i>Yes, that is the... okay.</i>
Teacher	<i>Right? And here I have the engine. And in other cases the engine is here. There. Sometimes there is also the gearing here... and instead of a window here the flooring is completely flat and here there are no seats or passengers.</i>
Student	<i>ah yes, yes, yes.</i>
Teacher	<i>What's the advantage? It is that when you raise this, you get seats here and on the sides, and people have to climb a step, and it's more complicated. Then, and that's why the side-views are so important, and that's why I was insisting on the floor-plan, when you use this view you see that the compartments of the wheels are wasted areas, right?</i>
Student	<i>Right...</i>
Teacher	<i>These are areas where in order to have a seat you must have something here... alternatively, the seat is higher again, and that's why you have all that stuff in the city bus, it's going around the technical stuff.</i>
Student	<i>But in the case... in the case of the tram...</i>
Teacher	<i>The case of the tram is a bit different. There, you have to consider that, and try to see in the photographs and go there again and observe it again and see where there are certain issues... why is the flooring so high?</i>
Student	<i>Mm-hmm</i>
Teacher	<i>What's going on down here. We don't really know but look...can we change it? If we change this architecture we might get there. Because it has a battery here...</i>
Student	<i>okay but then there is the issue of steep streets... which really –</i>
Teacher	<i>There is the issue of steep streets and the issue of the way the wheels are set in order for it to turn with a short radius, right?</i>

Case study 3 Albert & Paul

Design conversation 3

Student	<i>There it is, okay.</i>
Teacher	<i>And then there is here an issue of knowing that the tram must have an angle in the front, right? In order to be able to climb and go from ramp to ramp and another issue that includes, again, and again from a top-view, you have to see where the wheels are, I'm not sure if they're not slightly more inwards than this –</i>
Student	<i>Yes.</i>
Teacher	<i>– maybe they are, but there we have it, I'm not worried about dimensions but I am worried in making a proportional drawing (mdd reflection on action), generically proportional. In order to understand that it turns... here ...and that it will have a certain path, right? In buses, the wheels are further apart and that's why they don't fit in certain areas.</i>
Student	<i>Right, and that does not happen with the tram.</i>
Teacher	<i>And so, when you think about this type of strategy you can then understand what you can do inside okay? It's that thing again: you just have to consider that here there are these large cubes... to you it won't be more than that... areas in which we later have to work on. This issue of having big stairs, maybe it's... important to realise why... if you change the electrical system maybe we can have smaller engines and then the access to it is somewhere else, and then what I was asking was, imagine, this all goes up and now it's this lid that opens... when you take it to the workshop that's where you mess with it (smiles).</i>
Student	<i>Right..</i>
Teacher	<i>So, you were saying...</i>
Student	<i>That aspect of the maintenance...</i>
Teacher	<i>That aspect of the maintenance, right.</i>
Student	<i>Which was the maintenance of... mechanical maintenance, as it were, replacement of parts and...</i>
Teacher	<i>And the accessibility to those parts.</i>
Student	<i>Accessibility and replacement of... there, exactly, check-ups, that kind of stuff. And then, there is the issue of... cleaning, that is, there are two moments, let's say two cycles... one is the everyday cleaning, and a total weekly wash-up or something... and then, I don't know, annual check-ups.</i>
Teacher	<i>That's logical. Then, maybe, can I make a doodle here over your drawing? The issue of cleaning, that you mention there, maybe what you have to think about, at this moment, no matter what is going on underneath and the wheels, is that the tram in these areas here –</i>
Student	<i>Could have some curves (laughs)</i>
Teacher	<i>It should have some curves (laughs) ...the seats should also raise like you did here.</i>
Student	<i>Okay!</i>
Teacher	<i>It really helps the cleaning.</i>
Student	<i>Yes, yes, yes, yes.</i>
Teacher	<i>The seats could be attached to the side.</i>

Case study 3 Albert & Paul

Design conversation 3

Student	<i>Right, this comes a bit from the observation that...at the moment they're like this... and then it also has to do with the issue of the blind, of a textured flooring, if it would be easy to clean or if I would have to compromise.</i>
Teacher	Yes.
Student	<i>Of... this issue, which is that issue there.</i>
Teacher	<i>But there could be. If, if –</i>
Student	<i>The material, right?</i>
Teacher	<i>Yes, imagine, it doesn't have to be small spheres, because these are things with a very light relief.</i>
Student	Yes, yes, yes.
Teacher	<i>Something like this, this is very easy to clean and it is a differentiated flooring that someone can feel, that there is something different, now, with a drawing like this you can immediately see that issue.</i>
Student	Yes.
Teacher	<i>And say that this is round, and say that the flooring here has a little differentiation and everything is here. That's why it is good to always keep on drawing these things in this initial stage to understand the distribution... and here it's perfect, these are the right kind of sketches, to register ideas, layout drawings contain all the ideas.</i>
Student	<i>Considering cleaning, then I started to think about, basically, automatic-cleaning. That is, here you have... ah, right, floor cleaning and seats it's here... more or less... windows, and then support handles... that is, I've seen Italians, pick a handkerchief to hold the handle on the bus, or some other public transport, in this case it was a train. But I thought "okay, so, maybe it's the issue of A flew..." these are cultural issues... maybe to us... but okay.</i>
Teacher	<i>The question is that that material, that kind of inox, is quite resistant –</i>
Student	<i>Mm-hmm</i>
Teacher	<i>– but then when you touch it, if there is humidity or condensation and it's greasy and whatever, the feeling is unpleasant right?</i>
Student	Yes, exactly.
Teacher	<i>If you put some other coating there, so that you don't feel this...</i>
Student	<i>Maybe it's also connected with the issue of hygiene, right?</i>
Teacher	<i>Which is fundamental in a public transport.</i>
Student	<i>Therefore, right, I began to think about things that would automatically clean... windows... and hand supports and all that..</i>
Teacher	<i>Look Paul, what about this general layout, to make a zoom out.</i>
Student	Okay.
Teacher	<i>I like what I see here, what were you... proposing here?</i>

Case study 3 Albert & Paul

Design conversation 3

Student	<i>This, basically came from... from... both the necessity of the driver and the revisor, this was developed more towards the revisor, where here that first layout... appears again, that is, where... if the road is here, then here there would be the less space possible, then the revisor would be able to enter quickly and hold this support here, and then he could circle the whole tram while the tram was moving to check if all the passengers had their tickets validated.</i>
Teacher	<i>And this support point is upward/on top?</i>
Student	<i>It's upward. Exactly. So, okay, maybe I have to make another drawing (laughs)</i>
Teacher	<i>Yes, yes, I mean no, look, if you just had a section here –</i>
Student	<i>Exactly</i>
Teacher	<i>– then this would be understandable right? So, it's that thing, I got it now, but what about this here?</i>
Student	<i>Here, basically, the idea came from having the seats for people with reduced mobility up front.</i>
Teacher	<i>Mm-hmm</i>
Student	<i>There would be both the usual reserved seats and people who want to seat immediately, because maybe they can't make it to the back with the tram moving.</i>
Teacher	<i>Okay..</i>
Student	<i>So then they would have these handles... these handles above and basically... had... had all along the tram... following this whole front part until these benches. And here again they would have a... standing area.</i>
Teacher	<i>Okay, erhm...</i>
Student	<i>That is, here you would have benches on both sides.</i>
Teacher	<i>Yes. Yes, yes, yes. It seems to me, if you will, and from what I've discussed here with you at this moment, here this is a third layout, right? Because it's a bit different, what you do in terms of layout, it's 3 possibilities and there will be more. Now, at the moment it's not yet, and I know it's not supposed to be yet, this is just a pointing sketch but it would be interesting that you Paul would take this and tried to make it with a more or less correct proportion, that is, to understand if, in fact, how many benches can you fit there? –</i>
Student	<i>Ah okay.</i>
Teacher	<i>– maybe you can fit more. Maybe, and I don't know this by heart, but the total of a tram nowadays, I'm not sure how many seat rows it has, but imagine it's six or seven?</i>
Student	<i>No, it's less.</i>
Teacher	<i>okay. Let's say it's five, so, they're probably more than you have there. Therefore, it is important to fine tune this a bit. In a very simplified way, but understanding the proportions without over thinking it in terms of dimensions, but having a general idea... so, ideally, maybe you should print a floor-plan that has the dimensions, actually, you should print: top-view, side-view, and front-view, with the areas for the benches and doors, so that when you sketch you can have a sense of scale okay? And here, think about the driver as well.</i>
Student	<i>The driver, exactly. That is, erhm, there's the issue, mostly, of visibility.</i>
Teacher	<i>Mm-hmm</i>

Case study 3 Albert & Paul

Design conversation 3

Student	<i>That was erhm...</i>
Teacher	<i>To have a wider visibility.</i>
Student	<i>Visibility of the passengers, and visibility of pedestrians.</i>
Teacher	<i>okay.</i>
Student	<i>And then I thought, I don't know if it makes a lot of sense really to place the... the driver towards the centre... to find a way to... to organize this entrance. Then I began... but I really wasn't happy with this... all this because sometimes I've seen in the tram the driver has to get up to see if he is going to hit the car that is illegally parked to the right...and.. there, if for example in a car it makes sense that the driver is placed to the left because it is going to cross with other cars, right?</i>
Teacher	<i>Mm-hmm</i>
Student	<i>In the tram, maybe it would make more sense... to be on the right? I don't know...</i>
Teacher	<i>Then, Paul, maybe it's a bit what we've been talking about here, and to wrap-up, you have 3 different layouts, and maybe the driver, in one of those layouts, can be in a certain place. And maybe if you start to think about each one of those, for each one one thing or the other makes more sense. And this way you organize your information and begin, calmly, to aggregate ideas for concepts that are different and allow for different ideas. So, I would suggest that. I think you're going really well. Think about clustering these things and to do that the tool is clearly this: generic views, even though this is quite neat [the perspective] but some people can draw like this and others can't. And so, don't think you have to do a gorgeous perspective, no, for now, it's all about space organization. So I think this is interesting, let's try and see if it makes more sense in one concept or the other. It seems to me that it was interesting that you started in a random place and then you kept unravelling the ball of thread that lead you to all kinds of things. Don't forget, every now and then, to look at the overall requirements and see if the concept still includes everything, right?</i>
Student	<i>Yes, I started with people with reduced mobility and then it was for everyone!</i>
Teacher	<i>But there is no harm in that, you just have to start somewhere. And you arrived at several different concepts and that's what matters okay?</i>
Student	<i>Okay.</i>

Annex 4 – Full transcripts of case study 4

Case study 4 Robert & Patti

Design conversation 4

Teacher/ Student	Transcript
Robert	<i>Okay, I have already seen these.</i>
Patti	<i>These ones I don't think you've seen... so, I kept making sketches...considering possibilities...</i>
Teacher	<i>You were making zoom ins and outs. I think Albert already insisted a bit on the architecture –</i>
Student	<i>On the architecture... (simultaneously)</i>
Teacher	<i>– and in the issues, above all, of layout. There. And Patti, you already have here, some, some, some drawings of possible architectures is that it?</i>
Student	<i>Yes...</i>
Teacher	<i>And we already realised that in terms of capacity, the current tram is insufficient.</i>
Student	<i>It's insufficient.</i>
Teacher	<i>So, if the current capacity is insufficient, the first thing that comes to my head is: let's make it bigger. But if it's bigger then what happens? It won't fit in the city curves.</i>
Student	<i>Right. What if I did a caterpillar?</i>
Teacher	<i>That could be.</i>
Student	<i>Then it works, it has enough angle to curve. And it can be larger.</i>
Teacher	<i>Therefore, one: bigger vehicle. Doesn't work. Two: caterpillar, the caterpillar has an interesting aspect which is, during the day, and you probably reach this conclusion already, in the middle of the day there aren't many passengers. Right?</i>
Student	<i>Yes. There's fewer...</i>
Teacher	<i>Which means that during the day it could circulate with just one carriage. If it was an articulated bus it could leave one carriage in the station.</i>
Student	<i>If it was easy enough to unattach, and reattach...</i>
Teacher	<i>And then you can work on modularity, right?</i>
Student	<i>Mm-hmm</i>
Teacher	<i>There's another possibility. That doesn't have the same appeal to you, but that might generate a second concept; which is, what is the alternative to the caterpillar?</i>
Student	<i>Higher tram frequency?</i>
Teacher	<i>Exactly! Well, right there it means that you, have you noticed that you have two different concepts? You have one that is modular and therefore is based... notice that... this has a product/service relationship that is quite clear. Either I have a lot of trams circulating and it's a smaller thing; and at the end of the day I'm doubling the route's capacity. This is an option and it can lead you to a product. Right?</i>
Student	<i>Mm-hmm</i>
Teacher	<i>That product can be your concept. okay. And what about the difficulties you noticed during the route?</i>

Case study 4 Robert & Patti

Design conversation 4

Student	<i>Right, the delivery vans stop in the middle of the road, and then the tram doesn't pass.</i>
Teacher	<i>And when those vans are stopped, is there space for the tram to go around?</i>
Student	<i>No.</i>
Teacher	<i>Well, if it doesn't, then it's not worth it to change the rails, because it wouldn't fit anyway... well, considering that this is going to limit you, or constrain you, in the sense of being a challenge, because constraints can be great challenges. Considering that this will constrain your solution, then what solutions have you designed or thought about for now?</i>
Student	<i>(deep breath) I thought mostly about accessibility.</i>
Teacher	<i>Okay.</i>
Student	<i>That issue of it being high, I thought about several things... the issue of it coming down, I thought about having one of those electrical ramps that then pick up the man in the wheelchair and then he goes up and enters.</i>
Teacher	<i>Mm-hmm</i>
Student	<i>Something like that.</i>
Teacher	<i>Patti, can you explain to me what you mean by "the man in the wheelchair goes up?"</i>
Student	<i>(laughs) No, I, I...</i>
Teacher	<i>He doesn't do that does he?</i>
Student	<i>No he doesn't go up, IT goes up...</i>
Teacher	<i>What you're doing here, Patti, is a movement... okay, okay, this is automatic, I got it, I couldn't understand what you meant by "the wheelchair goes up", it's not the chair that goes up, it's this. okay, exactly. okay, nevertheless, it seems to me that, even though this is determinant, it's still secondary considering the total volume of the thing right?</i>
Student	<i>Yes, that's right.</i>
Teacher	<i>Right? Considering the whole package. I can have this working on a thing with 20 metres, or 3 storeys, or with a metre and a half length, right? There, so, even before that, how did you think about the size of the thing, in terms of proportion?</i>
Student	<i>erhm, first I thought when it comes down...</i>
Teacher	<i>Imagine that you're designing a tea pot. The first thing you'll think, about the tea pot, is: how much tea will it hold, right?</i>
Student	<i>hmmmm</i>
Teacher	<i>It's a constraint to think "to design this I will look for inspiration in the Renaissance". Before that you have to think "what's the purpose of this pot?" is it big or small? At the end of the day, that's what I'm asking you: how much tea will this thing hold?</i>
Student	<i>Yesterday I was thinking about that possibility, which was, keeping with the same language ... and dimensions...</i>
Teacher	<i>The dimensions or the language?</i>
Student	<i>The dimensions. There. How could we increase the space? And yet keeping it comfortable for elderly people, for tourists...</i>

Case study 4 Robert & Patti

Design conversation 4	
Teacher	<i>You talked with Albert about the several possibilities of concepts right? So, this is one. Closed. There.</i>
Student	<i>Yes. Erhm... the first thing was, ultimately, if we take some... seats... the tram now has two, two, two... and a row with two and a row with one. And, in the end, it's six seats here. Ultimately, maybe, if we take these six... it would be worth it to have 50 cm more standing space here, and it would be better, less "sardines in a can".</i>
Teacher	<i>Mm-hmm. Therefore, and you placed the handles there right?</i>
Student	<i>I, I, I have many possibilities. One: from more seats to more standing places.</i>
Teacher	<i>Mm-hmm</i>
Student	<i>And another issue, since this is a circuit than this tram doesn't have the problem of having to circle in both directions.</i>
Teacher	<i>Ah, it can move to both sides, right?</i>
Student	<i>Right. This part we can't use anymore...</i>
Teacher	<i>That's good thinking, you take advantage... if the tram only has one course... and there you capitalize on the space indeed. It looks like an option to me, the only thing I'm noticing here, considering what you've done, what is this thing here?</i>
Student	<i>Ah, this, this was the tube... so that people could grab.</i>
Teacher	<i>Ah okay okay</i>
Student	<i>And, since the windows are lower, I was thinking, the thing with trams is that you can open the windows and it's all very open. So then, if here the space are for standing, erhm, and there's the possibility of riding standing up next to the window it wouldn't make a lot of sense, it wouldn't be safe... so I thought...</i>
Teacher	<i>The windows should be the same as...</i>
Student	<i>So I thought about closing the window or just open it from the middle upwards...</i>
Teacher	<i>You can have a flexible window. That is, next to the seats or the standing places the window opens at different heights. That's interesting.</i>
Student	<i>Yes, also because one of the things I would like to have is visibility.</i>
Teacher	<i>Right.</i>
Student	<i>So...</i>
Teacher	<i>But then you have to think about a window that is fit for purpose, when the passenger is standing it doesn't go higher than this. When it's sitting down it won't work. This is one idea. What else?</i>
Student	<i>Another idea is that I wanted the seats to be retractable... but now that the teacher mentioned that, I was thinking that with the wall here it would hit...</i>
Teacher	<i>It would be worse right?</i>
Student	<i>Right, exactly. Other possibilities... another possibility is that the seats could come from the roof, that is, underneath it could almost be for storage.</i>

Case study 4 Robert & Patti

Design conversation 4

Teacher	<i>I think... I think it's cool... but then the issue is the distance to the ceiling. To support people... then it creates a leaver... this... a thing that is fixed to the roof and then with a force applied here... this is a huge force. Naturally it is a nightmare. Any force that you apply here... but what we were talking about before about the retractable seats. Naturally, not against the wall of course, but for example: the ones that are in a line like this, right? These can be retractable.</i>
Student	Yes.
Teacher	<i>And that space can be used somehow, between the seats to carry more people standing.</i>
Student	<i>And will people get up to have more standing places?</i>
Teacher	<i>Well, there is a possibility which is the driver just goes there and locks it. Again, this is product/service, the driver could push a button and lock it. Done.</i>
Student	<i>One way to solve the problem of the seats coming from above would be if there was... if it was supported to the wall here, and then here in such a way that people could grab it there. And then this could still be a place... a place for storage...</i>
Teacher	<i>Look, I think you already have some ideas here. We have flexible windows, retractable seats as well, or not. But let's say, the overall product concept, is more or less the same. It is an improvement right?</i>
Student	<i>So far! (laughs) I wanted more...</i>
Teacher	<i>It is an improvement in which you wanted to keep the language and make some improvements on the inside. It's all fine by me. With the variations we just talked about. This is concept 1. Concept 2?</i>
Student	<i>Right, that's it... I was... thinking first in all the possibilities and then I would combine them so that I would have several concepts.</i>
Teacher	<i>So, you don't have enough information yet to have a second concept, is that it?</i>
Student	<i>Right...</i>
Teacher	<i>Because all of this here is more or less the same, right?</i>
Student	<i>Right. I think I'm a bit stuck... to the image of the tram.</i>
Teacher	<i>Right. But it's a possibility. It's connected to the image of the tram but with improvements. This is one is done. With improvements and whatever, I think it's great. I think that working with these things here... this could generate other product concepts, right? It's not just a new concept for an interior. It's a new product concept.</i>
Student	<i>Right.</i>
Teacher	<i>If it works, it can lead you to new paths... for example, if you consider the issue of frequency, or the issue of the caterpillar, you can even have variable caterpillar modules according to the time of day. Whereas this one that you've been working on is a bit inflexible because it's the same product throughout the day, this one can have different typologies of caterpillar, that is, the caterpillar carriage of the end of the day, or middle of the day. Summer caterpillar carriage. Maybe the basis of the carriage is always the same, right? But it could be built with other stuff attached; imagine that the tram at some time of the day always carries children, and other times it doesn't, you can have the tram going to the station and change carriages to one with smaller seats that can hold a lot more children. For example. But it's a completely different concept. In frequency, in size, in functioning.</i>

Case study 4 Robert & Patti

Design conversation 4

Student	<i>Yes, but the caterpillar can have those possibilities... it could even have an elderly people area, another one for tourists...</i>
Teacher	<i>And maybe it can be developed within this language... and it would be the "Lisbon caterpillars". The Lisbon caterpillar. This is really cool! To wrap up, I think you have one with several ideas, with the same language, it's your safe proposal, right? And I think you should work on one of these two. And notice that the further upstream you go, that is, the further you work on the usability the more innovative your concept will be. The further you work on the final product the less innovative it is, because it's just working on details.</i>
Student	<i>Ah, I get it. Yes.</i>
Teacher	<i>Right? If you start even before considering the layout, that's where you can make something completely new. If you start saying that "oh, but a tram looks like this, or that". If I would've said "ladies and gentleman, let's design a tram", right? Then you would start with this (points to typical tram). And this results in a so and so level of innovation. Improvements. But if we begin from the usability, right? You can improve by designing a product that is not merely incremental. It's a lot more. And I think you're still missing, I wouldn't say 3, if you can make 3 then fine, but I think you still only have the first one, erhm, we had suggested a group of 3 proposal but, I think you're still in the first one. I think you should try to extract another one from there. okay? I've seen you have a lot of side-views, I've noticed they're all very similar, very inspired on the current tram, which isn't bad, but I would like to see something completely different.</i>
Student	<i>Ok. I'll do it now.</i>
Teacher	<i>It's now?</i>
Student	<i>It's now!</i>
Teacher	<i>Then do it, and keep up the good work.</i>

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About the author

João Ferreira was born on February 7th in Lisbon, Portugal. He obtained a master's degree in communication design from the Faculty of Architecture of the University of Lisbon (2009), and holds an undergraduate degree in Product Design from the same University. During his undergraduate course, João spent six months as an Erasmus exchange student at the Ecole Supérieure des Arts Saint-Luc Liège in Belgium.

In 2011, João received a doctoral grant from the Foundation for Science and Technology in Portugal to begin his PhD research at the Delft University of Technology under supervision of Henri Christiaans; later, Rita Almendra (University of Lisbon) and Paul Hekkert (TU Delft) joined as promotor's of the PhD research. João's research centred on design education; specifically, the studies concentrated on teacher-student interaction in the design studio setting.

During his time as a PhD student in Delft, João was involved in the development of the Retail Design specialization in the design and architecture faculties of the University of Delft, where he was an assistant and lectured in design studio classes. Also, João occasionally works as a freelancer in communication design projects. Finally, João developed a research interest in academic writing from the supervision of graduate students as well as from the process of writing his thesis and research papers. He is particularly interested in developing methods to help students enhance their proficiency and clarity in written expression.

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