Designing Objects and Texts:

an exploratory examination of narratives, texts and reflecting on difference inside product design projects

The Open University
Department of Engineering and Innovation

A thesis submitted in accordance with the requirements for the degree of Doctor of Philosophy

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This thesis is a result of my own research and does not include the outcome of collaborative work, except where stated otherwise. The dissertation has not been submitted in whole or in part for consideration for any other degree.

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Abstract

This dissertation involves an exploratory examination of student product design projects, through the lens of narrative modes of discourse, where objects are understood as particular forms of text. This position is predicated on understanding the paradigm of design as a social practice. The product design project results in a variety of concretised outputs, understood as texts, including drawings, sketches, models, prototypes, as well as accounts and reports of experience, from a variety of perspectives. In sociolinguistic terms, texts arise because of difference, which is made apparent through reflections on identification, analogy, opposition and ascertaining resemblance across experiences of events and the components of which they are comprised.

A mixed methods approach combines empirical case studies of postgraduate product design projects adopting a macro-structural perspective, combined with a micro-situational accounts of intermediary tutorials between students and their tutor, reflecting upon project developments, through discussions involving sequences of events, comprised of particular actors engaged in action in a place and time. A grounded approach reveals multiple narratives in the product design project, where the prototypes in progress are examined and interrogated as participants themselves involved in shaping the narrative frame.
Analysis provides the design difference framework, involving 5 production rules associated with a product project that addresses the narrative transition. These involve decomposing, characterising, rewriting, cohering and recomposing. The provisional framework is discussed, suggesting that the application of production rules results in difference, evident in the negotiation between extant determined objects in the world, and abstract, determinable concepts in the mind.

A final discussion regarding the theoretical framework presents a reflective critique of the thesis, and discusses contributions made and future work to be undertaken.
It is often said it takes a village to raise a child. This seems an appropriate analogy to represent the process of a PhD, but as Deleuze suggests, the analogy also hides some difference…I’ll get to that soon enough.

I’m fortunate that I live in a large village, and there’s been so much support from every corner of the community. There are too many people to explicitly name and thank here, but I hope that all my neighbours realise that in their own small way, I am indebted to them for helping to make this final work possible, and I will do my utmost to thank them.

Every village has a council of elders, those to whom we turn for guidance and support. Prof. Claudia Eckert and Prof. Chris Earl have been that council for me. At times pragmatic, sometimes insistent, always insightful and every so often infuriating, I’ve come to realise the depth of their patience, kindness, support and understanding — and as much as these are enduring qualities in their character, it’s also been my actions which have likely called the need for these virtues to be demonstrated (especially the infuriating part). The story I’m about to tell in these following pages owes a great deal to them, and without whom I wonder if the story might have been told. Thank you is an impoverished response to the gifts they’ve given me.

Villages may raise children collectively, but at times this process has made me feel like I’m more the village idiot, and I’m sure at times (too many times!) my actions would corroborate
this characterisation to others. Fortunately, for me, one person has continued to be able to see beyond the idiot and recognise the individual, trying, struggling and persisting to make sense of what is around them, though I’m sure I’ve done a very good job to make this task difficult. I owe a lifetime of gratitude to my partner Olwen (and to Honolulu, Twinkie, Major Tom, Bob and Red) for the unwavering and unconditional support, kindness and patience. Though my name sits on the cover page as the final author of this work, there is no way this would have been possible without her enthusiasm for being the co-author of our lives together.
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You should begin with a discipline, even if it is arbitrary, because the site is so screwy - you can always break it open later.

(Schön, 1983)
1.1 Introduction

Product design is a tough business. It’s tough to learn, tough to do, and tough to teach. Product designers consider our interactions and experiences with the material world, endeavouring to address our needs, hopes and desires, by breaking things down, moving things around, and putting everything back together. Product designers contend with the richness of the world, representing its complexity through various methods and media in order to progress their projects forward, and in doing so are often having to decompose the world into smaller, manageable components, removing some of that richness, to get at the heart of their project’s challenge, aims and objectives. The quote from Schön that opens this chapter is attributed to the studio master Quist, helping the student apprentice Petra examine her work in order to reframe it, allowing for a suitable outcome to reveal itself. Situations are examined, questions are posed, responses are outlined, things get broken, replaced and retried. One of the first rules of product design is to iterate, and as the idiom goes, if at first you don’t succeed, try try again.

1.1.1 The stories we tell ourselves about product design

Researchers examining product design practices have provided great insights into understanding how product designers work as they continually reconfigure our material and object worlds. Studies have provided macro level observations associated with a longitudinal view of the practice (Bucciarelli, 1988, Cuff, 1991, Minneman, 1991, Yaneva, 2009a, Storni et al., 2015), through to micro level experimental interventions that give us detailed information about complex processes associated with cognitive and socio-cognitive strategies employed in situ during design activity itself (Akin and Lin, 1995, Cross and Cross, 1995, Goel, 1995, Kan and Gero, 2008, Hansen et al., 2009, Dorst, 2011, Kokotovich and Dorst, 2016).
Much of the micro-level studies of practice in action recognises and builds upon the understanding that designing has a strong relationship to reflective activity (Smith et al., 2009, Goldschmidt et al., 2010, Schoffelen et al., 2013, Adams et al., 2016a, Adams et al., 2018). These perspectives are building on the seminal work of Schön (1983) and his case study of Petra and Quist, from which the opening quote of the chapter is drawn. In doing so, most researchers attempt to account for the richness within the design space described in the opening paragraph (Baaki et al., 2016), to understand its impact and influence on designers’ addressing and progressing their projects, particularly when situated in a studio-oriented approach to examining design activity. However, many of these studies seemingly assume that the format of the traditional, studio environment, and all its richness, will endure.

Prior the global health pandemic taking hold at the end of 2019 which required most higher education to be delivered exclusively digitally and remotely, the traditional studio approach to design teaching and training in many disciplines was already undergoing significant change. Expensive capital expenditure for materials and studio equipment is getting harder to justify, and smaller staff compliments delivering rich experiences to increasingly larger cohorts of students requires a way of doing things differently. The traditional studio model of design education, as a place to explore and reflect through projects developing material responses to immaterial challenges is quickly disappearing, and with it, the rich tacit experiences of these material engagements.

There have been growing calls from academics and industry professionals outlining why the current approach to design education might require change, vocal among them being Don Norman. He suggests:

*Service design, interaction design, and experience design are not about the design of physical objects: they require minimal skills in drawing, knowledge of materials, or manufacturing. In their place, they require knowledge of*
the social sciences, of story construction, of back-stage operations, and of interaction. We still need classically trained industrial designers: the need for styling, for forms, for the intelligent use of materials will never go away. (Norman, 2018)

Norman’s call for change resonates with me. With an undergraduate degree in social science, and many years of design education and training, I cannot recall practicing anything resembling the scientific method, nor can I claim that I’ve ever really solved any particular problem for anyone. I completed my postgraduate design studies in the Netherlands at a renowned design school, taught and supervised by many professional designers aligned to the Dutch design collective Droog Design. The teaching of design was done through projects, which consisted of two distinct but related outcomes: the product, and its associated story.

From a cultural and historical perspective, the work of Droog Design, its various designers and its place in Dutch design history is well reviewed and documented (Betsky, 2008, Thomas, 2008, Escallón, 2012, de Rijk, 2015, Rossi, 2015). Much of this perspective places emphasis on the material culture significance of Droog Design as a critique of contemporary design practice, material consumption, the aesthetics of production, and the ways in which these designer projects promote a form of storytelling through objects as a key, supplemental part of their practice (Escallón, 2012).

Wanders’ "Knotted Chair”, originally designed under the auspices of Droog but now under license to Italian furniture production house Cappellini, is a prime example of the supplemental relationship between the artifact and its associated story. At first glance, the chair doesn’t seem to be solving too many problems, and this becomes more clearly evident when one is provided an opportunity to sit in it for any period of time. It is, without doubt, an enduring icon of 20th century product design, profiled extensively through images in catalogues, internet blogs and books about contemporary furniture and design. In a very real sense, the story of the chair, through its image, circulates more than the chair itself, which remains largely inaccessible to
the general public. The major function of the chair is not addressing a problem of seating, rather, it is to tell a story and present a range of opportunities for people to reflect, and consider their own systems of value with regards to contemporary furniture design, production and consumption.

1.1.2 Projects and narratives, or problems and solutions?

There is arguably more emphasis in the design research literature on problems, than projects. In practice, however, it is projects that are managed, and in higher years of undergraduate design education, the emphasis moves towards the project itself, with the product, prototype or other outcomes being one of the overall project outcome or deliverable. Empirical studies of design projects are difficult to engage, since they involve a significant amount of time, often beyond what researchers are able to commit in their examinations. Just like designers do, researchers decompose projects into smaller problem-solution situations that can be more easily examined, allowing design researchers to understand the cognitive capabilities required to generate solutions in these rich, complex, multi-media environments. And just like design, this decomposition into smaller units necessarily involves a trade-off in removing some of the richness associated with the practice under examination.

As researchers strip away the material richness associated with the traditional studio approach associated in product design projects, we’re left with talk and discursive interaction. Recently, scholars have begun examining talk and conversation within design practice, (Glock, 2009, Oak, 2011, McDonnell and Lloyd, 2014), primarily through an ethnomethodological lens (Garfinkel, 1967, Sacks et al., 1995), seeing discourse as a situated action that helps to shape and structure the situation, often supported and affected by the richness of materials in the scene, including drawings, models and prototypes. These rich media artifacts, that play an important role in framing discourse and knowledge, have been described as inscription devices
boundary objects (Star et al., 1989, Star and Griesemer, 1989); conscription devices (Henderson, 1991); as well as intermediary objects (Vinck and Jeantet, 1995, Eckert and Boujut, 2003, Brassac et al., 2008). In these instances of examining talk-in-action in situated design practices, the modes of discourse of exposition, description and justification and the impetus of their examination, often supported by material devices, remains at the level of the problem, not the project. Narrative, as the 4th mode of discourse receives significantly less attention (Bruner, 1991).

Is it possible to understand the practice and process of product design, taking place inside of projects, in terms of stories and narratives, whilst not contradicting the popular conception of design as a problem-solution paradigm? (Dorst and Cross, 2001). Hansen et al suggest, from their professional experience, that alternative approaches to considering design might be worthwhile:

...in our professional practice as design teachers we experience that it is not always productive to view a student design team as a rational problem solver. We may need a different description or additional descriptions of design to capture those situations (Hansen et al., 2009).

The types of challenges that product designers and teams are being asked to address is becoming more difficult to frame as a problem which needs to be solved. Challenges such as the UN’s Sustainable Development Goals (SDGs) are reasonably framed as “wicked problems” (Rittel and Webber, 1973), by which we mean that various, interdependent and sometimes contradictory ways are available to define the problem, with a multitude of descriptions, explanations, and justifications arising based on the contextual framing of the challenge itself. In these approaches to designing, we see problems nested inside the project, with assorted problem-solutions at varying scales available, and the project being a complex set of activities aimed at ascertaining which one is appropriate. Bruce Archer’s PhD thesis (1968) examined the nature of the project in his examination of the design process, and outlined 227
activities across 7 distinct project phases (for a visual illustration of Archer’s overall design project checklist, see (Dubberly, Feb 4 2016)). Jack (2013) discusses the nature of engineering projects from a more contemporary perspective, highlighting the variety of participants (managers, stakeholders, customers, technicians, etc); outcomes (drawings, plans, prototypes, tools, etc.) and activities (implementation, testing, documenting, integrating, etc.) associated with managing and delivering projects. Wanders’ *Knotted Chair*, discussed earlier, is a project which examines the complex entanglement of the systems of production, consumption and personal value. Problem-solving activities are clearly important; the position of this thesis is to add new ways of thinking about this very important aspect of through considering the problem-solution space as an event, inside the project, which might be accounted for through narratives, stories and experiences.

In short, the project could be understood as the context in which problems are addressed, solutions are provided, and that one significant outcome is the unfolding of the problem and solution, through a narrative or story about the problem in context. In this way, the stories designers tell about the projects they undertake might also be viewed as a design outcome itself, highlighting key moments of insight, approaches to development, as well as highlighting sticky events where problems emerged, requiring solutions in order to progress. This approach is often adopted in understanding design practices and processes through semi-structured interviews with practitioners reflecting the nature of their profession (Lawson, 2004, Lawson, 2006, Lawson and Dorst, 2009, Blackwell et al., 2009, Eckert et al., 2010), who are encouraged to tell their stories and experiences of practice.

### 1.1.3 Reflecting on difference

But these retrospective reflections on projects by professional designers are somewhat different than the types of reflection often studied by design researchers, which Schön discusses in his
examinations of improvisational approaches to ill-structured problems. His concept of reflecting-in-action is summarised as a “conversation with the materials of the situation” (Schön, 1992b), generated from the case study of Petra and Quist mentioned earlier.

In that case study, we see what Quist is doing as he helps Petra understand how she can formulate the situation in a new way, revealing new opportunities to reframe her problem, and move it forward in exploring potential solutions. What we don’t have the opportunity to hear is what Petra thinks, since Schön does not outline what Petra is reflecting on. At some point after this tutorial interaction, she will continue with developing her project brief, constructing and providing a response through a presentation to a jury of peers from within the profession, who will assess her work. But what will she tell them, what will she outline about her experiences over the course of her project where she can identify that she has started to acquire and learn her specialist practice? At the conclusion of the project, she will, in effect, reflect on her experiences and share the story of her project with the jury, both the story of the process through her models and drawings, and the sense she’s made in of the experience in the studio which has informed this particular instance of work. She will select the events and practices which are relevant to the development of the response, and conveniently ignore those that aren’t, reflecting not only on her efficacy as a designer in the moment, but as a narrator of the story of her design, after the fact.

Others have posited that models, drawings, and other material constructions emanating from design practice can be understood as texts (Coyne and Snodgrass, 1992, Coyne et al., 1994), things read by an audience but also written by the designer. But where do these texts come from? How did they arise? Sociolinguists and semioticians suggest that all texts arise from difference (Kress, 1989a, Kress, 1992, Kress, 2010), resulting from a need to account for the particular, which is contrary to general expectations or intentions. The 4 modes of discourse mentioned earlier allow for the particular, this difference to be described, explained, justified,
as well as understood through narrative. In generating texts, arising from difference, whether they be written, oral or other forms of media commonly found in the product design studio, I argue that difference is what is being reflected upon, as reflection is understood as a key competency of designing in practice.

1.2 The Research Question

Understanding design practice as a social activity, where projects involve stories told and narratives exchanged as carriers of information and as material outputs being designed, allows us to shift away from the predominant view of design as a problem-solving activity, notwithstanding the importance of this perspective. A project based perspective allows for problem-solutions to be considered, but provides broader scope to understand that project stories and narratives are also important. A project based perspective provides a frame which highlights the possible role that narrative might be playing, both in the recounting of past experiences, but also in the projection of potential future ones, through the products being considered, constructed and eventually requiring dissemination. Design projects deliver more than objects, but an assortment of texts in the broadest sense, putting the objects into particular contexts through the stories of their rationale, purpose and meaning. These stories highlight particular, important aspects about these objects in order to differentiate them from others.

1.2.1 The driving question

In framing product design practice in this way, from anecdotal experiences and a cursory introduction to some foundational literature, our primary research question emerges, namely:

How can we understand and contend with the richness of design practice encountered in the design studio, particularly in the
educational context, through the talk and conversations that takes place in and around it?

1.2.2 Overview and Structure of the Dissertation

In addressing this question, 4 core themes are evident in our question, forming the core of our examination:

- design projects, as the field of inquiry
- reflection, a core competency associated with iterative design practice
- narrative, or stories, reports and texts which are generated as outcomes associated with the design project
- the different textual and narrative possibilities, which are being evaluated and reflected upon

In order to examine these particular themes, an appropriate structure of research activity was put in place. What follows is a descriptive summary of each chapter in the dissertation which provides an account of the overall thesis structure.

Chapter 1 has already introduced a number of themes situated around examining design projects as opposed to briefs; considering narrative spaces as opposed to problem-solution spaces; embracing a perspective that all manners of texts inside projects arise because of difference; and a recognition that what difference is what is being reflected upon when engaging the practice of design. The structure for the remainder of the thesis, where these concepts are defined, placed into context and scrutinised is outlined below.

Chapter 2 presents the literature review, which starts by examining 4 key concepts extracted from our introduction and motivation: namely the design project, reflection, the narrative, and difference. A definition of the project and its application in pedagogical development is highlighted in discussions of project-based learning when discussing design practice in the social paradigm, contrasted to problem-oriented perspectives. Reflection is a cornerstone activity associated with the acquisition of skills in design education, and also outlined as being
a key competency of professional design activity. Its relationship to project-based learning, and its narrative formats are outlined. Concretising is a key aspect of the product design project, highlighting the delivery of a number of outcomes and outputs, one being an object prototype outcome, the other being the account or story associated with the development of the artifact. These accounts and stories are, in part, generated through reflection and presented as narratives in transition, predicated on an action-oriented structure consisting of a sequence of events, temporally strung together (Todorov and Weinstein, 1969, Labov, 1972, Bruner, 1986, Polkinghorne, 1988, Riessman, 2008). **Narratives** and their relationship to reflective practice and design projects is discussed. The ways in which prototypes operate as both project outcomes, and as carriers of the evolving new narratives is considered. Semiotic production, language, talk and conversation are involved in delivering and exchanging various narratives amongst actors and stakeholders during project development. Key concepts such as inscription devices (Latour, 2005), conscription devices (Henderson, 1991), boundary objects (Star et al., 1989, Star and Griesemer, 1989), and intermediary objects (Vinck and Jeantet, 1995, Vinck, 2012) are presented, and highlight the nature of dialogue, talk and conversation involved with building collective understanding about the objects and prototypes being developed. Narratives are based in experience being reflected upon, and the interactions between actors in the event create multiple perspectives about the prototype, leading to multiple, different narratives. **Difference** is a precursor to generation of text, which includes objects and artifacts in development in the project space. Difference is described, discussed and its importance to design projects, reflection and narrative transitions outlined. The literature review provides a critical review of related work in these areas as they appear within the design research field, examining design education and professional development context. Gaps are identified, and the clarified research question presented.
Chapter 3 introduces the research methodology, outlining key epistemological positions which help to frame the relevant perspectives, gaps in knowledge and research question outlined in the previous chapter. Perspectives on qualitative and quantitative approaches to research are outlined, and mixed methods approaches, particularly useful in design research, are presented. Methodological challenges and critical research perspectives relating to the examination of reflection, narrative analysis and difference, are presented. An overview of the research methods to be employed in the study are presented, including case study and content analysis, linkography and network graphing, and the adaptation of a particular approach to analysing narrative transitions through Quantitative Narrative Analysis (QNA).

Chapter 4 opens with a series of student case studies based in a postgraduate product design studio. The cases presented have taken place over one academic year, where students have been engaged in a personal project, leading to the presentation of a series of outcomes, including prototypes demonstrating their concept, and an annotated "design book” which provides a structured account of their overall project undertaken and outcomes delivered. This macro level analysis of the project discusses a selection of materials associated with coursework production, starting with an introductory project outline in written form the start of the academic session, a poster presentation providing a visual perspective on initial project considerations and motivations on the part of the student, a timeline of interactions between the students and their academic tutor to foster project development and progression through prototyping development, and finally the summarised project accounts captured in the students “design book”, replete with images of finalised prototypes, design and research processes, and justification of design decisions made. An outline is established involving the macro-level structure of project progress and highlights an approach to projects understood as involving narrative transitions. A micro-level account of interactions involved in realising the transition
is not forthcoming in this approach, requiring a micro-level analysis of interactions inside the project to provide more detailed accounts of the project and narrative transitions.

Chapter 5 shifts focus to the intermediate tutorials between the students and the tutor in the studio environment, to examine them for approaches to design moves being made in the conversational exchanges which foster the narrative transitions outlined in Chapter 4. The approach adopted to start the examination involves framing the tutorials as protocols, and engaging protocol analysis. Linkography is a useful design research tool that employs graph theory to see relationships and connections between design moves, and the tutorial transcripts are subjected to this approach, using a “common sense” coding scheme linking utterances together. Further approaches to graph theory employ alternative software packages to broaden the approach to the datasets and the intuitively driven approach to coding. Graphs are visualised and metrics created, but the approaches remain inconclusive in the findings. Some incorrect assumptions involving the homogeneity of texts and discourse is outlined as a problematic in the application of this approach, which relies on inter-textual phenomena, whereas the tutorials are engaged in turn-taking conversations and extra-textual perspectives out with the tutorial interaction. The experience of design practice, and its implications on transitions and progression is under discussion, but design itself is not engaged in these sessions. Another method or approach to addressing the conversational transcripts based on the intuitively adopted coding scheme based on constituent parts of a story grammar is found in Quantitative Narrative Analysis (QNA) which is discussed and applied in Chapter 6.

Chapter 6 returns to the tutorials and beings to examine the narrative structures composed of bags of words through parts-of-speech, to ascertain dimensions of difference appearing in the construction of the narrative transition. The event is outlined as being decomposable into a set of smaller constituent parts, centred on an identified subject, engaged in action, with or towards some object. The tutorial conversations presented and the inductive coding scheme employed
in the chapter 5 case studies highlight these features, since they are a staple component of the English language system, facilitating various modes of discourse. The structure of the event, and the sequencing of events, is outlined as corresponding to a story grammar in the abstract sense, which is seen in application in the transcripts of conversations in a practical sense. Here, our analysis examines transitions through a story grammar perspective using Quantitative Narrative Analysis, or QNA (Franzosi, 2004, Franzosi, 2010). QNA allows for the examination of changes across texts, highlighting difference in the use of language across speaker utterances, seeing a shift within general parts of speech, whilst utterances still conform to the overall grammar of narrative discourse in practice. Rewriting as a rule of producing new statements in response to the environment is evident in language use throughout the tutorial interaction and this is discussed as a parallel activity in material constructions and prototype developments in product design practices being examined.

Chapter 7 continues to employ a modified perspective to QNA to examine a new set of tutorials between the student and the tutor, at a later date in the academic calendar. This subsequent tutorial brings the student back into the studio with the tutor to discuss their developments, progress, and their experiences and insights drawn from having other people interact, test and examine their project work prototypes. A number of things have changed in this space, with the student continuing to work according to a project timeline, whilst the tutor has not. The involvement of others, effectively operating as new narrators, provide their accounts to the prototypes in a similar narrative frame, requiring the student to understand the perception that others have on their rewriting activities. Employing our QNA approach to the transcribed text, we see multiple narratives taking place, with the introduction of these new narrators, requiring some manner of managing the results of an others decomposition and rewriting practices. Difference again is manifest in the opposition between the ways in which the various narrators decompose, rewrite and understand the same sets of events and objects, requiring some form
of activity to reconcile difference and make things coherent. The approach adopted by the student in cohering the prototypical object and the experiences of others is outlined and discussed.

Chapter 8 summarises the work done within the thesis in bringing together the summaries from across Chapters 4 through 7 into a consolidated framework addressing product design projects when seen through a lens of narrative transition, situated in reflections on difference, and outlines how it consolidates these initial findings. The framework is employed to present a perspective in product design projects facilitated by an action-centric approach involving narrative thinking, but also critiqued in terms of what it is unable to address.

Chapter 9 concludes the thesis and provides a personal reflection upon the work undertaken here. The research question is reviewed, and an account of successes and shortcomings of the design difference framework in addressing them is reviewed. The approach to the thesis overall, both positive and negative, as well as its contribution to knowledge about design practice and design education is addressed. The chapter concludes by putting forward new questions based on the work done so far, positing future work for the continued development of the design difference framework based on its success in addressing our examination of design projects, narrative transitions and reflecting on difference.

1.3 Mapping the Dissertation

The various chapters outlined in the previous section will be used to address the driving question in the examination of reflecting on different narratives and their associated texts within product design projects. The mapping of the four themes (project, reflection, narrative, difference) and their relationship to the various chapters was discussed in the previous section.
Below, in Figure 1, a visual mapping of that relationship is provided to help identify and summarise the thesis structure at a glance, going forward.

Figure 1: The Dissertation Roadmap, mapping research themes to the respective chapters where they are discussed.
Chapter 2

Literature Review

...I shall draw from a particular example descriptions of designing which underlies the differences among schools and suggests a generic process shared by the various design professions. I shall consider designing as a conversation with the materials of the situation.

(Schön, 1983)
2.1 Introduction

This chapter provides a review of the relevant literature, in establishing our overall thesis project direction. A literature review is an integral component of every dissertation. It allows for the identification of the academic communities to which work eventually makes a contribution, but also from which it draws its knowledge and understanding of the subject, helping to establish the foundations of the thesis. This dissertation critically examines the ways in which design practice is taught and learned in a product design studio, situated in an UK institution of higher education.

In the introductory chapter, the motivation and the rationale for undertaking this dissertation were outlined; namely, how does experience of design projects and the associated narratives which are being disseminated through outcomes correlate to the accounts of design practice encountered in the design research literature, which places significant emphasis on problem-solution interfaces within design? If reflective activity is a key feature of design competency, what are designers reflecting upon within projects and the project narrative? It was articulated that addressing these questions may lead to novel insights informing contemporary approaches to design education, helping young designers become more effective in their emergent practice, where emphasis is placed on product design projects being managed, rather than emphasizing problem-solution encounters, responding to pre-established product design briefs. In Chapter 2, the literature review will provide insights from prior knowledge and insights related to our domain of interest, through a systematic review of the literature using identified keyword searches, bibliographic analysis, combined with an organic review of the literature returned in the systematic search to understand and address the various nuances, and different
understandings of the relevant keyword terms, across the various scholarly domains and lines of inquiry that are associated with the systematic keyword search.

4 key concepts were touched upon in the introduction, leading to some preliminary questions which I intend to refine over the course of this chapter. First, it was asked what can be learned when product design practice is structured as a project-oriented activity as opposed to an orientation as a problem-solution exercise. Second, product design projects involve a breadth of activities over time, which result in various types of outputs which complement the prototypes and artifact models, including reports, presentations exhibitions and other forms of communicative dissemination. These are collectively referred to as texts. In the sphere of design education, student projects often result in summaries of temporally based project accounts, contained within a design book. To what extent do these stories or narratives of the project also constitute design activity, developed over extended periods of time? Third, if we accept that the project account, story, or narrative is equally part of the design practice and process, does this impact our understanding of the practice of reflective development in constructing these accounts, stories or narratives associated with the design project? And finally, insofar that reflection is a key aspect of design activity and practice, what is being reflected upon when considering the stories and narratives of a transition towards the designed outcomes and outputs? If difference is what brings texts into being, can it be suggested that designers are ultimately reflecting upon difference?

A review in this chapter of the relevant literature aims to examine these 4 key concepts, leading to the research question which will drive our inquiry, towards deeper understanding, of the ways in which design projects foster narrative constructions, and the role that reflective activity plays in this process and practice. Our first step is to identify the relevant literature across this broad subject, in order to "... to build an argument, not a library " as Rudestam & Newton suggest (Rudestam and Newton, 1992). To do this effectively, the review will outline a
rationale for searching through particular literature selected. There are a number of approaches to conducting literature reviews. Boell & Cecez-Kecmanovic (2014) differentiate between the literature review as an outcome in its own right, or as the result of an active process of searching. With respect to the review as process, they suggest that adopting a hermeneutic frame allows for an iterative process to review which provides an outcome having relevance, meaning and focus. Their framework suggests that emphasis on "...small sets of highly relevant publications is preferable over huge sets of documents whose relevance cannot be sufficiently judged" (Boell and Cecez-Kecmanovic, 2014). Webster & Watson (2002) espoused a similar perspective which places value on topic-based searching, as opposed to searches isolated to publications and disciplinary specificity. A dissertation centred on research into design, particularly focused in education and acquisition of relevant skill involves knowledge and insight from across a variety of disciplines. As such, this dissertation also adopts a topic or concept-centred approach to the literature review, in order to consider the scope of contributions which may be informing the scope of the study.

2.1.1 Thematically oriented co-citation analysis

The themes which have already been identified within the introductory chapter can help to set the stage for the remainder of the chapter. The themes are reduced here to 4 key terms which helps to structure our literature search, relevant to the field of design. These are:

- The project. The project forms the scope of our examination where design activity is taking place
- The narrative. The narrative frames the examination, as it is being developed within the overall project scope
- Reflection. Reflection is a key activity within design practice, and it is also the key activity under examination in our research frame upon which design practice is structured.
- Difference. If reflection is a core activity in design practice we are examining, the thesis argues that difference is what is being reflected upon, and
understanding these narratives of difference is at the core of this research project.

I suggest that the 4th term, difference, does not inform the search itself, as much as it begins to inform the analysis of and the question derived from the search itself. In this context, the thesis examines product design students, engaged in personal projects which attempt to tell a story about the transition between the current situation, and a preferred future situation, associated with the development of an artifact, object, or prototype that addresses the transition between these situations. The accounts by design students tell of their design decision-making, development practice, and reasoning are situated in differences between things. The nature of this difference, I will argue, is what the thesis is intent upon examining.

An initial search through Web of Science was conducted, employing a Boolean search of 4 terms: designer, project, reflection and narrative. The initial search string is outlined below:

\[ TS=(\text{Designer}^* \text{ AND Project}^*) \text{ AND } TS=(\text{Reflect}^* \text{ OR Narrative}^*) \]

The search string evolved through a variety or iterations. The initial search involved the exclusive Boolean term ('OR') of the same 4 terms, which returned more than 4 million results, clearly far too many to be useful. Ultimately, the search was refined to encompass any article which included both the term “designer” or its plural variant (i.e. designers) AND project (or its variants) AND to include one, or other, of the terms reflect (and its associated variants) OR narrative(s). The search phrase selected for a focused scan of the literature returned a total of 669 references, across a range of disciplinary perspectives, from a range of texts, conference papers and academic journals. The top 10 domains in Web of Science from which this literature was returned is are outlined below in Figure 2.

---

Before analysing all 669 retrieved records individually, a co-citation analysis was constructed, a data mining approach that enables insight into a large body of literature by seeking connections within the literature based on the frequency of common citations within their respective bibliographies. The value of co-citation analysis is outlined by White & McCain (1998). The approach adopted here is similar to the work of Chai et al. (2012), and Beck & Chiapello (2017), both specific to the design domain. It also draws influences from the work of Ullmann (2015) examining reflection and writing, particularly in the domain of education. The co-citation matrix for this review was constructed using an open source application called Sci2 (Team, 2009), and visualised using Gephi, an open-source network graphing application (Bastian et al., 2009). A full description on how to use Sci2 can be found with Weingart (2015). The top 30 scholarly works returned from in our co-citation analysis, as well as the top 30 works which are co-cited together most frequently, is found in Table 1. These results are visualised, highlighting their relationships, in Figure 3. In this visualisation, the nodes represent individual authors, the links represent the degree to which connected authors are cited together, and the various coloured nodes are clusters, identified through a community clustering algorithm within the Gephi software (Blondel et al., 2008) that establishes degree of node relationships within the network graph.
<table>
<thead>
<tr>
<th>Author</th>
<th>Frequency Cited</th>
<th>Cited Author</th>
<th>Co-Cited Author</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rittel (1973)</td>
<td>16</td>
<td>Rittel (1973)</td>
<td>Schon (1983)</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1: Top 30 works in the thematic co-citation analysis including their weighted relationships
Figure 3: Network graph of co-citations based on keyword literature search

The premise of a co-citation analysis is to determine patterns within the literature dataset using a structured and replicable approach, rather than attempting to verify a method of arbitrary selection of work from the literature when starting a review. In that vein, our cursory examination of the co-citation matrix results in Table 1 above reveals that the most cited work in our co-citation matrix, the largest node in the visualisation, is perhaps unsurprisingly, Donald Schöhn's *The Reflective Practitioner* (1983). The seminal work of Schöhn was highlighted in the introductory chapter, particularly the case study of the design tutorial in the architecture studio between student Petra and master Quist.
From a design research perspective, the co-citation matrix highlights a number of well-known names, who easily correspond to the data in the co-citation analysis generated by Chai et al. (2012), whose work was limited to one particular journal, *Design Studies*. For our purposes, this provides a very narrow view of design, and this is a result of a restrictiveness in our initial search term returning specific results examining designers and their projects. To expand our view, a second search was conducted, expanding our initial term from “designer” and its variants, to search all terms involving design, and its variants, which would necessarily include the terms from our initial search, but open up to include texts and articles which contained keywords including design, designs, and designing, encapsulating work which encapsulated a broader view of design as a practice, and outcome, performed by various specialists. The expanded search term is outlined below.

\[
TS=(Design^{*} \text{ AND Project}^{*}) \text{ AND } TS=(Reflect^{*} \text{ OR Narrative}^{*}).
\]

This second search returned a total of 13,801 records, a markedly significant increase from the 669 returned from our earlier search. To make the matrix more manageable for processing purposes, this search was filtered to include only journal articles and conference proceedings: monographs, reviews and other texts were removed, and this reduced our dataset to 8884 records. 1049 records did not have citations attached, and these were removed, reducing our expanded dataset size further to 7835 usable records. The top 10 academic domains from which this literature was retrieved in Web of Science is illustrated below in Figure 4.
Sci2 (Team, 2009) was again used to construct this expanded co-citation matrix, and the dataset was exported to Gephi for further processing and production of visualised relationships, providing graph metrics of degree (number of connections), modularity (community clustering between related nodes) and edge weight (number of times a co-citation pair appears in our co-citation matrix). A new set of tables outlining top 30 citation frequency and top 30 weights of co-citation pairings is presented in Table 2 and a new graphic visualisation of the expanded graph generated by Gephi is presented in Figure 5.
<table>
<thead>
<tr>
<th>Author</th>
<th>Frequency Cited</th>
<th>Cited Author</th>
<th>Co-Cited Author</th>
<th>Weight</th>
</tr>
</thead>
</table>

Table 2: Top 30 records from expanded thematic search of Web of Science
An initial review of the domains listed in Figure 4, as well as the graph generated from the co-citation matrix entries from this expanded search, there are a number of returned records from disciplinary domains and research findings which do not clearly align with the interest of this thesis, in part due to the structural ambiguity of our search terms, including design, and reflect (and their variants). This ambiguity of terminology led to the retrieval of records in medical science discussing projects involved with the design of optics and the reflecting of light. The modularity clustering algorithm in Gephi was able to identify these communities, which were filtered from the citation matrix before generating the final visualisation and comparative tables.
of records listed above. The isolation of 14 communities resulted in a final matrix size of 338 citations (nodes) with 414 connections (edges) between them, when including only co-citations which occurred three times or more, as outlined by their edge weighting. A final figure, Figure 6 is extracted from the disciplinary alliances of authors found in the co-citation matrix, is presented, highlighting the degree of cross-disciplinary perspectives which are found in the search literature returned from Web of Science, predicated on the foundational literature contained in their collective bibliographies.

Figure 6: 15 largest community clusters derived from co-citation matrix modularity metrics

Understanding the foundations of the literature returned will enable for a more thorough examination of the subsequent (and relevant) design research literature in order to critically examine this foundation, and how it has been built upon by others, including the epistemological stance, theoretical positions, and the methodologies employed by others in this thematic clustering of the literature. This involves returning to the original results and organising the searches appropriately and identifying the critical papers which will reduce and tighten the scope of the study. The identified themes which constitute our respective search
term will be discussed individually, allowing to frame the various components of the study in more detail, leading to an articulation of our research question, but also methodological approaches which are associated with those questions. In the remainder of Chapter 2, I will discuss “what” this design study is about based on the foundational literature identified in the expanded co-citation matrix, as well as combing the actual literature returned from the search itself. Chapter 3 will follow from this discussion, articulating the “how” and the “why this way” concerns involved with our thesis examination.

So what does this mean, and how does it help us progress any actual review of the literature in a thematic way, in order to understand how others have engaged research into design projects, the importance of reflection, and the relevance of a narrative frame in this examination? It becomes clear through the comparison between these two systematic searches that there may be various ways of engaging design within research, and research within design. The appearance of a significant clustering of citations in trans-disciplinarity is perhaps testament to this idea, that design might be considered beyond the traditional conventions that are signified by “designers” alone.

As a result of expanding our search criteria with respect to design, some significant differences in our literature database for review has emerged. First, Schön remains the most significantly cited author in both searches. However, many of the authors from the original search no longer appear as prominently in this expanded search. Notably, only 8 of the cited authors from the original thematic search appear in the expanded search: 2 works by Schön (1983/84, 1987), Dym (2005), Kolb (1984), Arnstein (1969), Lave (1991) and Glaser (1967). The remainder of the top 30 recorded citations are notably very focused on design research in the context of designers doing design, and their cognitive engagements with these tasks. However, in our expanded citation list, a higher frequency of citations emerges from authors engaged in qualitative oriented research strategies, including case study research (Miles 1994; Yin
2003/2009; Stake 1995 and Eisenhardt 1989); Grounded Theory (Glaser 1967/1967; Strauss 1998); qualitative research analysis and methods (Braun 2006; Patton 2002; Lincoln 1985); qualitative health research (Hsieh 2005); situated knowledge and practice (Lave 1991; Wenger 1998; Brown 1989; Weick 1995); education and pedagogy (Kolb, 1984; Freire 1970; Dym 2005), the sociology of science (Star 1989; Latour 2005) and philosophy (Bandura 1986; Dewey 1938). Notable authors which are most frequently associated with design practice are Schön (1983/1987), Rittel (1973) and a group of authors under the title Design-Based Research Collective (2003). Figure 6 presents the top 15 communities of citations, organised thematically through a reading of their abstracts and keywords, from the expanded search criteria used to generate the expanded co-citation matrix.

Within design research itself, there exists various paradigms of thought which have driven differences in approach to understanding what designers do in their practice, and how this may impact the methodological positions required to study these differences paradigms. An early account of various paradigms of design can be found with Mitchell (1994), describing a transition between understanding design as problem-solving activity, knowledge-based activity, and ultimately a social activity. Dorst & Dijkhuis (1995) identified two primary paradigms associated with thinking about design practice, with their study attempting to clarify how these paradigms aligned with accounts of actual design activity, rather than theoretical perspectives.

...the treatment of design as a reflective conversation lacks the clarity and rigour achieved by the rational problem solving paradigm...

The theoretical base of this theory should be developed further, though, (e.g. building a taxonomy of design problems, and of frames) so that more rigorous and generalizable conclusions can be drawn from this. There is no theoretical reason why this could not be done. (Dorst and Dijkhuis, 1995).
More recently, Stumpf & McDonnell (2002) discuss 4 paradigms, each involving three key elements (designer, design task, design process). The 4 paradigms see design as: rational problem-solving; social process; hypothesis testing; experiential learning. In their own view, they attempt to find common ground between design as a social process and design as experiential learning:

*Our research addresses the problem of applying an argumentative approach to understand the process of experiential learning in design teams during the early episodes of designing. As part of this approach we emphasise that designers make use of persuasion as a linguistic skill connecting them to their community and culture as they design in a team.* (Stumpf and McDonnell, 2002)

The overview of the 4 paradigms as outlined in their paper is presented in Table 3.

<table>
<thead>
<tr>
<th>Description</th>
<th>Rational Problem-Solving Paradigm</th>
<th>Social Process Paradigm</th>
<th>Hypothesis Testing Paradigm</th>
<th>Experiential Learning Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Designer</td>
<td>Problem Solver</td>
<td>Group Facilitator</td>
<td>Scientist</td>
<td>Practitioner</td>
</tr>
<tr>
<td>Nature of Design Task</td>
<td>structuring ill-structured problems into manageable components</td>
<td>seeking consensus</td>
<td>establishing proposition</td>
<td>values driven</td>
</tr>
<tr>
<td>Macro Level Design approach</td>
<td>Problem Decomposition</td>
<td>Consensus Building</td>
<td>verifying of propositions</td>
<td>determining best fit</td>
</tr>
<tr>
<td>Micro Level Design Approach</td>
<td>Iterative Search</td>
<td>argumentation</td>
<td>experimentation</td>
<td>cycles of construction</td>
</tr>
</tbody>
</table>

**Table 3:** Descriptions of 4 paradigms of design and prescriptions for design practice within those paradigmatic frames. Based on Stumpf & McDonnell (2002)

Working from this table, the Rational Problem-Solving paradigm is most often associated with the work of Herbert Simon (1996) and the Experiential Learning Paradigm most often associate with the work of Schön (1983). The work of Dorst and Cross, through their seminal “Delft...
“Protocols” study (Dorst and Dijkhuis, 1995, Cross et al., 1996, Dorst and Cross, 2001) was understood as a way of consolidating these two oppositional paradigmatic approaches to the field. The Hypothesis Testing paradigm, where design is practiced akin to the scientific method, is perhaps best represented by perspectives on research through design, in our original table represented by Gaver (2012).

Approaches to these 3 paradigms are evident within the Table 1 summary from our original search, all emphasise the individual designer. Design as Social Process, the 4th paradigm described by Stumpf & McDonnell, and echoed by Mitchell, is indicative within our co-citation matrix by the work by Rittel & Webber (1973). This paradigm, I argue, is the one most relevant to this thesis, situated in our conceptual framing of design projects emphasising narratives, reflection and ultimately difference. Rittel & Webber’s paper, in outlining the attributes of design and planning in the face of “wicked problems” suggests designers often act as facilitators in a group or team, engage the participation of others, work towards consensus building, build plans as their prime focus, and operate from a systems perspective. Within our original co-citation search, more recent work by authors such as Sanders & Stappers (2008); Simonsen & Roberston (2012); Vines et al. (2013) and Manzini (2015) all exemplify more recent publications which prevalently emphasise an approach to design situated in the social.

In this context, the scope of our literature review becomes clearer, and is situated in communicative aspects of product design practice, with an emphasis on understanding how designers are operating in the realm of the social. Such processes involve time, place, actors and objects, engaged in practices in project form, where planning, negotiation, argumentation and framing are involved in coming to some form of consensus, as designers navigate complex systems involving others. These process components of agents, actions, time and place also form the basis of narratives and stories of lived experiences, the foundation of the work of social science scholars, such as Glaser, Strauss, Lave, Yin, Wenger, Star and Latour, all whom
are prevalent within our expand search of the literature. But the relationship between narratives, stories, cases and accounts of design practices and processes as outputs of design themselves are less prevalent in our original search of the citation literature, or at least, such approaches are appearing much later teleologically.

2.2 Examining the Literature

The co-citation analysis, both the original and, in particular, the expanded search, have provided us with a significant volume of literature to review, and to some extent the job has been made easier by clustering related literature and mapping this to our thematic search, through various paradigmatic approaches to design as activities involving problem-solving, experiential knowledge, structured modes of reflective inquiry, as well as planning and organisation practices. This has provided us with an initial scope to our study, drawing across a variety of domains including education, engineering, business and organisational studies as well as social sciences based in the humanities. The articles returned from employing our thematic keyword search are categorised in one primary domain in Web of Science. The appearance of multiple keywords that corresponds to our search terms highlights various relationships domains might have across our themes, leading to cross-disciplinary approaches. A community clustering algorithm was employed in our graphing exercise across the literature, to find the scale of the communities and their relationships to each other, corresponding to the visualised domain graphs constructed in Figure 6. This relationship between domains and themes has been mapped below in Figure 7.
Embracing the paradigm which considers design as a social activity, our 4 key search terms drawn from our thematic search can now be examined, drawing from the scope provided through our co-citation matrix records, and the relationship between keywords, academic disciplinary domains, and degree of concern represented by the scale of each node in our mapping in Figure 7. In the remainder of this section, I will outline a rationale from the literature which informs the structure of our methodology, data collection, and data analysis exercises, which will be more fully accounted for in later chapters.

2.2.1 The Project
As outlined in the introduction in Chapter 1, personal experience as a designer suggests that designers more often engage in projects, in which a variety of problems might be embedded. From this rational, we begin a more thorough examination of the project, including a definition, an outline of its structure, and how it has been embraced within the educational context as a pedagogical approach to learning design, and how this differs from a problem-based approach in the acquisition of design knowledge.

Examinations of project work are situated in primarily qualitative, social science literature, often marked by studies involving ethnographic accounts of situated practice, theoretical accounts of education and pedagogy predicated of experiential knowing, case study accounts of projects, organisation and approaches to planning, and records of situated knowledge and practice, involved with social participation and collaboration.

From a design perspective, Schön’s case study of Petra & Quist is perhaps one of the most significant case study accounts about the project. Schön derives his conceptual development of "reflecting-in-action" from this case, which is situated around a student project taking place in a first year architecture design studio. A brief description of the project is provided by Schön, outlining the "…loft-like studio space…” (p79) where 20 students are working simultaneously in "…private, parallel pursuit of the common design task" (p80). The coursework begins with Quist introducing all the students to "…a 'program' - a set of design specifications, in this case, for the design of an elementary school, and a graphic description of the site on which the school is to be built" (p.80). The coursework concludes with a juried evaluation consisting of Quist himself and a panel of external critics, in an event known as "…a 'crit'…” (p80). Between the start and end of the coursework, the studio master reviews the student’s work for progress, and troubleshoots identified challenges allowing students to progress. The remainder of the case study outlined by Schön is structured around one particular tutorial. The rest of the project, and the events which structure it, seem inconsequential to
establishing his concepts of "reflecting-in-action" based on the solitary interaction between Petra and Quist. Despite a further lack of emphasis about the project in this seminal study, the centrality of the project to design practice and design education, as discussed by others, is considered here.

Projects are common spaces of inquiry into design activity, but the nature of a project itself has been subject to little particular scrutiny or close examination. Often, projects are understood as temporal events where designers engage in practices of responding to briefs (established or constructed), formulating positions for process engagement, leading to presentations of their final outcomes (Papadimitriou and Pellegrin, 2007). Vial highlights the centrality of the concept of “the project” to the design disciplines in suggesting that:

...one can say that architectural objects (buildings) and design objects (technical objects) cannot do without the project as a required intermediary. The epistemological value of this statement has not been sufficiently evaluated. It clearly establishes that in design and architecture, there is a necessary and consubstantial link between the project and the object, that is to say, it is impossible for one to exist without the other (Vial, 2017).

With this in mind, it would be advisable to provide some working definition of “the project”, and some description of its structure, before commencing with a basic assumption that such a ubiquitous term is understood, agreed and accepted by others.

The Association for Project Management (APM), the accredited body overseeing membership of professional project managers provides this definition of a project:

A project is a unique, transient endeavour, undertaken to achieve planned objectives, which could be defined in terms of outputs, outcomes or benefits. A project is usually deemed to be a success if it achieves the objectives
according to their acceptance criteria, within an agreed timescale and budget. Time, cost and quality are the building blocks of every project.\(^2\)

Turner defines the project as a form of temporary organisation, seen as:

> An endeavour in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives (Turner and Müller, 2003).

In her comparative examination of project-based learning and problem-based learning in mathematics, Dahl sets out her definition of a project being:

> ...usually defined as a task that has a specific goal, the time frame and resources are limited, the organisation about the project is temporary, the solution requires multiple disciplines, and the task requires more than one person to complete (Dahl, 2017).

From a professional practitioner’s perspective, L. Bruce Archer’s 1968 doctoral thesis provides insight into the nature of the design project through his examination of the management and situated activities associated with the product design process, outlining a list of 229 discrete activities taking place over 7 distinct phases of an overall project [Dub] (Archer, 1968, Boyd Davis and Gristwood, 2016). Archer’s 7 phases involve Preliminaries; Briefing and Programming; Data Collection and Analysis; Synthesis; Development; Continued Development; Communication; Winding Up. The mapping done by Dubberly Design Office\(^3\) implies the prevalence of the basic components outlined in our definitions above, namely the existence of multiple stakeholders, engaged in plans of action, identifying resource constraints and limitations required to lead towards the intended goal, within a finite period of time.

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\(^2\) From [https://www.apm.org.uk/resources/what-is-project-management/](https://www.apm.org.uk/resources/what-is-project-management/). Accessed November 1 2020

\(^3\) See also Dubberly Design Office for a graphic overview recreated in .pdf format at [http://www.dubberly.com/concept-maps/archers-design-process.html](http://www.dubberly.com/concept-maps/archers-design-process.html). Accessed August 10, 2018
However, these definitions of the project don’t necessarily contradict, or supplant, approaches to the problem-solving paradigm within design practice and research. Hatchuel provides a useful account which suggests that projects are useful in considering “expandable rationality”, where the notion of the problem and a requirement to define, consider and re-define it fall within the scope of an overall project (Hatchuel, 2001). With this in mind, it is useful to consider that what we are aiming to uncover here is not necessarily a binary opposition between project and problem-based approaches to understanding design practice. Rather, we suggest that problem-based approaches are generally subsumed within a project scope, where projects involve a multitude of problems under examination, subjected to reframing, within the evolving contexts of the project parameters, which include encapsulations of time and resource, the development of a plan and set of actions which lead to eventual goals, a set of criteria for evaluation project success, and a multitude of stakeholders and agents having involvement and responsibility at various times and stages during project delivery.

With an outline of the concept of the project now available, a loose structural outline and its importance to professional practices, particularly in creative design disciplines associated with the built environment, we turn to examining the relationship between the project and the educational environment where design skills are acquired, applied and practiced.

From a general pedagogical perspective examining how students best learn, Blumenfeld et al. (1991) present their views on the value of project-based pedagogies in fostering an appetite for learning. They outline two essential components of projects in the learning environment. First, a driving question allows for the structuring of activities, and second, some form of artifact or product is generated as a representation of the knowledge acquired and applied in addressing the driving question. In short, according to the authors, project-based pedagogies are beneficial since “the doing and the learning are inextricable” (1991). Artifacts (whether it be products, papers, presentations, or some other form of material generation) are concrete and explicit,
which allows for the student to share, disseminate and engage in critique with others to allow for reflection on decisions made in their plans, widen their perspectives and knowledge base, and develop improved artifacts in the process.

Thomas’ through review of the literature associated with project-based learning (herein simply referred to as PBL) highlights further that the nature of the driving question and the ability to address it remains authentic; teaching is more facilitative than instructive, and is situated within a community of cooperative learning, fostering reflection to support acquisition of real-world skills (Thomas, 2000). However, Thomas notes that PBL does not consist of a homogenous pedagogical approach. There is variation across a range of implementations, raising questions about the characteristics of the “types of doing” that qualify as useful project structures in order to ensure learning experiences remain active and fruitful. A recommendation by Thomas outlines that projects within PBL should:

- be central to the curriculum, not peripheral
- emphasize a leading question which drives students to engage with central concepts within the discipline of practice
- allow for inquiry and investigation of a constructive nature to examine the driving question
- provide a high degree of student autonomy in engaging the project
- be situated in real contexts and circumstances and challenges

Dym et al. outline that inquiries into project-based learning, at least in the US, had to do with the 1997 National Science Foundation report providing an action agenda into reform into engineering education, calling specifically for increased attention to “…among other things, teamwork, project-based learning (PBL) and close interaction with industry” (Dym et al., 2005). The authors’ review presents a comparison of institutions that implement PBL approaches, notably Aalborg University in Denmark. However, per Thomas’ concerns above, whilst Dym et al. are discussing PBL as project-based learning, Aalborg outlines PBL as “problem-based learning” situated in “project oriented delivery”.
Mills et al (2003) provide an overview of project-based learning in engineering, from an Australia perspective, driven also by the impetus to align engineering education to industry oriented professional practice. In their review, they highlight similar ambiguities in the inconsistent usage across project-based and problem-based learning. In their work, they examine a number of Australian based higher education engineering programmes, but also return their discussion to Aalborg in Denmark. The authors make a clearer distinction regarding the Aalborg curriculum, in articulating that project-based teaching has a strong orientation towards addressing a particular problem. They outline a distinction between project-assisted learning and project-based learning, the difference being the degree of direct instruction and content control by the staff involved in teaching. They refer to Perrenet et al, who present a critical examination of problem-based vs project-based learning from the Netherlands, tasking which perspective is more appropriate for engineering education. Mills et al summarise this study, highlighting:

...differences that they noted included:

- Project tasks are closer to professional reality and therefore take a longer period of time than problem-based learning problems (which may extend over only a single session, a week or a few weeks).

- Project work is more directed to the application of knowledge, whereas problem-based learning is more directed to the acquisition of knowledge.

- Project-based learning is usually accompanied by subject courses (e.g. maths, physics etc. in engineering), whereas problem-based learning is not.

- Management of time and resources by the students as well as task and role differentiation is very important in project-based learning.

- Self-direction is stronger in project work, compared with problem-based learning, since the learning process is less directed by the problem. (p. 348)  

(Mills and Treagust, 2003)
These studies of project-based learning primarily discuss aspects of engineering education at the undergraduate level. The primary requirement for entry to a postgraduate programme is an undergraduate degree of high standing (often in the same discipline). It is expected that a personal, undergraduate dissertation project, what Dym et al. refer to as a “capstone project” (Dym et al., 2005) will have already been undertaken, and completed successfully to a high standard. All authors discussed above indicate that as undergraduates students in engineering progress through their academic careers, it is considered helpful and appropriate that teaching migrates from problem-based learning in the beginning towards project-based learning in final years (Perrenet et al., 2000, Thomas, 2000, Mills and Treagust, 2003, Dym et al., 2005). It might be interpreted that this trend towards self-directed projects is appropriate at postgraduate study, where a degree of competence has already been previously acquired, and an increased level of expertise is being pursued (Dorst and Hansen, 2011).

The examination of the literature makes clear that project-based learning complements problem-based approaches, notably in allowing students to take ownership of their learning experience through problem identification, project organisation and the overall process towards the generation of appropriate responses as goals and project outcomes. It fosters alternative, but equally important, competencies for designers, including teamwork, collaboration, interdisciplinary practice, planning and communication. This hides the complexity of project management, particularly because no two projects are the same, nor should they be if this approach to teaching is to remain effective (Mills and Treagust, 2003).

This uniqueness of each project, whether across the students university career or into their professional life, highlights a requirement of contextual understanding of the circumstance in which the project is embedded. As outlined by others, expertise in project management and delivery often means drawing on previous experience in addressing the current, ill-structured circumstance. To that end, a significant part of teaching at postgraduate level, in developing
greater expertise, is to help frame experiences that challenge assumptions that mastering
process models such as IDEO’s 6 step human-centred design process or the "double-diamond"
from the UK Design Council will automatically result in good design projects. Dorst puts it as
such:

But knowing that model doesn’t make these students designers at all: to train
them in design we have design studios, where we give them multiple design
projects in which they learn to grapple with different kinds of design
problems, with different design contexts, and with themselves as designing
human beings. The art of design is to deal with these other aspects of the
design activity, the ones that a process model so conveniently ignores. That
is the price one pays for abstraction...(Dorst, 2008)

Dorst describes a set of activities in the design studio which involve critical engagement with
the problem, through projects, as a manner in which educational practices bring students into
understanding the language and practice of the discipline, through safe and structured
construction of experiences. However, as Dorst attempts to point out, it isn’t simply following
the recipe that leads to project success. It isn’t useful, he suggests, to think that any experience
in the project space is useful to learning. Rather, reflection on experience is required in order
to ascertain how the project approach and decisions taken are relevant and appropriate, and
which of these experiences within the project are useful to foster useful learning and knowledge
acquisition. One approach to this learning through experience, fostered through reflection, is
the Kolb’s pedagogical model of experiential learning. Kolb’s work is discussed by Dym et
al. (2005) in their reviews of PBL, and Kolb also appears as the most highly cited pedagogical
model in our co-citation matrix. In the next section, I discuss the relationship of this important
concept to the project, as a central feature for understanding experiences generated through it,
through the authors who have contributed to aspects of understanding reflection and experience
through the relevant literature to design.
The discussion of project-based learning (PBL) raises some confusion, when some authors refer to PBL as problem-based learning, apparently conflating these two approaches. Table 4 below provides a comparison of the literature reviewed at this point and summarizes key points that distinguish between projects and problems.

<table>
<thead>
<tr>
<th>Paraphrased as</th>
<th>Problem (n)</th>
<th>Project (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>approach</td>
<td>break in action (Schon)</td>
<td>plan for action (Rittel)</td>
</tr>
<tr>
<td>locus</td>
<td>active framing (Dorst)</td>
<td>navigating various frames</td>
</tr>
<tr>
<td>form</td>
<td>individual</td>
<td>collective</td>
</tr>
<tr>
<td>reflection</td>
<td>knowledge cascade</td>
<td>knowledge waterfall</td>
</tr>
<tr>
<td>output</td>
<td>in action</td>
<td>on actions</td>
</tr>
<tr>
<td>knowledge generated</td>
<td>solution</td>
<td>goal</td>
</tr>
<tr>
<td>mode of discourse</td>
<td>ontological; declarative (what is)</td>
<td>experiential; procedural (what happened)</td>
</tr>
<tr>
<td>result</td>
<td>description (characterization)</td>
<td>account (narrative)</td>
</tr>
<tr>
<td>structure</td>
<td>solution state is often unknown</td>
<td>goal state is often agreed in advance</td>
</tr>
<tr>
<td>definition</td>
<td>a situation that isn't desired;</td>
<td>sequence of events leading to change</td>
</tr>
<tr>
<td></td>
<td>a matter or situation regarded as</td>
<td>an individual or collaborative</td>
</tr>
<tr>
<td></td>
<td>unwelcome or harmful and needing to</td>
<td>enterprise that is carefully planned to</td>
</tr>
<tr>
<td></td>
<td>be dealt with and overcome;</td>
<td>achieve a particular aim; a proposed</td>
</tr>
<tr>
<td></td>
<td>PHYSICS•MATHEMATICS - an inquiry</td>
<td>or planned undertaking; a piece of</td>
</tr>
<tr>
<td></td>
<td>starting from given conditions to</td>
<td>research work undertaken by a school</td>
</tr>
<tr>
<td></td>
<td>investigate or demonstrate a fact,</td>
<td>or college student.</td>
</tr>
<tr>
<td></td>
<td>result, or law.</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: An outline of key attributes regarding project-based or problem-based approaches to designing

2.2.2 Reflection

If design projects are the site which provide for experiences on which to learn, reflection is the cognitive activity associated with internal validation about how those experiences are structured, ordered and made sense of. Reflection is discussed as a significant design competency, and in this section, I provide an overview of how design research has engaged reflection, particularly following on from the significant accounts of Schön. The section reviews relevant models of reflection, primarily drawn from pedagogy and education, and
Reflective thinking is generally attributed to John Dewey (1933). As one of the seminal figures of the American pragmatist movement in philosophy, Dewey believed one’s view of ‘the world’ was predicated on one’s appreciating and understanding it through experience and inquiry. In contrast to a view that the world was objectively real and ‘out there’, the pragmatists understood that knowledge of the world was derived from direct experience of it, and such knowledge was often very individual in nature, and hard to declare. Experience came through acting in the world, driven by personal belief structures and value systems, in part shaped by earlier experiences and how we came to make meaning from them, through reflection.

Dewey posits reflection as a type of thinking situated in inquiry and critical examination of experiences, shaped by actions, in phenomenological rather than rationalist perspectives. He starts with two conditions which underwrite reflective operations:

\[\text{(a) a state of perplexity, hesitation, doubt; and (b) an act of search of investigation directed toward bringing to light further facts which serve to corroborate or to nullify the suggested belief (Dewey, 1933).}\]

van Manen (2006) provides a more detailed outline, presenting a cyclic process of reflective thought extending Dewey’s position above, involving five steps: 1) perplexity or doubt; 2) conjectural anticipation; 3) examination of possibilities; 4) elaboration of hypothesis, and; 5) doing something, a plan of action.

Reflective thought is rooted in examination and making meaning from experiences, in order to shape new foundations of beliefs, which structure our actions. Dewey outlined this thinking as an internal process of consideration of the past, evaluation of the consequence and possible change in foundational principles which drive future actions. This perspective can be
characterised as actions leading to new knowledge, yet remains in the mind of the individual. This approach has had a significant impact on theories in education, and also contributes to theories driving design research. Here, we examine it within the confines of the project, which was presented in the previous section. In line with design projects, through project-based learning, reflection is a critical competency allowing for reflecting on experiences and how knowledge from the past might be applied in ill-structured and ambiguous circumstances in the present.

Design research, as stated earlier, is understood to be examining design practice in order to facilitate improvements, leading to better design and better designers. I’ve already accounted for the various paradigms of thought regarding design practices, through our examination of design as a social process based on argumentation, facilitation and collaborative activity (Mitchell, 1994, Stumpf and McDonnell, 2002). A particular form of reflective activity embraced within research into design practice community, Schön’s reflecting-in-action, was presented as a counter to the rational problem paradigm from initially described by Herbert Simon. "The Reflective Practitioner" (Schön, 1983) was introduced earlier in the introduction through the anecdotal accounts of personal design practice.

Within design research literature, there is a great deal of literature addressing the concept of reflecting-in-action, drawn from the case study of the interaction between Quist and Petra (Schön and Wiggins, 1992, Schön, 1992b, Gedenryd, 1998, Dong, 2007, Glock, 2009, Jahnke, 2012). The analysis by Schön is arguably attractive to many in design research since it resonates with the experiences of the majority of mature practitioners who have undergone a studio-based, arts-oriented education (such as architecture, fashion design, graphic design, product design, etc). The case study of Petra and Quist focuses on a moment in time during the student project, the tutorial in the architectural studio. The importance of this work by Schön is exemplified by Cross and his outline of the nature of design activity (1999b). Here,
Cross outlines 8 perspectives on design which are drawn from wider research perspectives in the literature of the time, drawn from methodological work including interviews, case studies, protocol studies, theorising and experimentation. The underlying perspectives suggest to Cross that design is rhetorical, exploratory, emergent, opportunistic, abductive, reflective, ambiguous and risky. Many of these perspectives can be traced back to the Petra/Quist interaction, which are often supplied as evidence of the strength of the case study as articulating design activity itself. Regarding reflection, Cross explains:

...the relationship between the internal mental processes and their external expression and representation in sketches...Acknowledging the dialogue or "conversation" that goes on between internal and external representations is part of the recognition that design is reflective... (Cross, 1999b).

This emphasis on dialogic aspects of design conversation, implicating that design is reflective, is a direct reference to Schön’s work, where Schön states:

In a good process of design, this conversation with the situation is reflective. In answer to the situations back-talk, the designer reflects-in-action on the construction of the problem, the strategies of action, or the model of the phenomena, which have been implicit in his moves (Schön, 1983).

Schön’s view of reflection is quite focused, providing an alternative to the conventional approach to reflecting on actions, whereby someone has time following the action to engage the process of considering those actions. For Schön, reflecting-in-action is a form of decision making activity, drawn from expertise and experience, in circumstances where time to reflection-on-actions may be not available. Experience gained, as a reservoir of prior knowledge which is potentially transferrable to current circumstances, can be seen to be easily developed through project-based learning approaches, as discussed by others (Blumenfeld et al., 1991, Perrenet et al., 2000, Thomas, 2000, Mills and Treagust, 2003, Dym et al., 2005, Kokotsaki et al., 2016).

Within the co-citation matrix, a number of approaches to reflection and reflective activity are evident across a number of domains. In the domain of organisational management, the work
of Kurt Lewin and his model of Action Research is highlighted. Action Research has its roots in social development, where communities were given power to address new futures that impacted them through changes driven by participatory actions (Lewin, 1946), aiming for community emancipation and positive, collectively driven change. From an institutional perspective, the field of Action Science, developed by Argyris & Schön (Argyris and Schön, 1978), examined ways in which institutional learning, decision making and ultimately positive change could take place within an emancipated workplace.

Reflection is also an important education and pedagogical construct, an important competency to be fostered as part of an inquiry-driven perspective on learning. Two important models which appear within the co-citation matrix involve understanding reflection as circular, or iterative practice. These involve the work of David Kolb and his model of experiential learning (Kolb, 1984) and the deliberate experiential model of learning from Boud, Keogh & Walker (1985). By contrast, the work of Mezirow and Associates (1991) involves a model of critical reflection that sees the practice in a hierarchical format, culminating in a position of critical reflection, involving a practice of reflecting on reflection itself.

These various models are introduced here to outline the importance and the influence of the concept of reflection, but the concept is not without its criticism. For some, the concept remains unclear (Kember et al., 2008); the use of terminology associated with its description is inconsistent and its application lacks rigour (Rodgers, 2002) and there remains a lack of critical engagement with the concept itself (Eraut, 2006, Hébert, 2015). Despite these challenges, the examination of reflection within design research, particularly design pedagogy, remains an important topic of examination, whether it involve the examination of team-oriented reflection during designing (Valkenburg and Dorst, 1998); designer sense-making relating to ill-structured problems and circumstances (McDonnell et al., 2004, Chou and Wong, 2015); how it is fostered through the use of various media such as journals, drawings and model
making (Currano and Steinert, 2012, Kurt and Kurt, 2017, Calvo, 2017, Deininger et al., 2017); how it is managed in response to feedback and skills development in the context of design education (Adams et al., 2003, Laschke et al., 2015, Cardoso et al., 2016, Tracey and Hutchinson, 2016); and its structure as and relationship to narrative construction (Sunday, 2018).

Despite the important work and contributions to understanding reflection, and notwithstanding the critical insights outlined here, access to reflection, as a mode of thinking, remains elusive and challenging to identify independently to verbal reports about what designers and design students are thinking about, or how they are thinking about things. Reflection, like other modes of thought, is best made apparent through language. This perspective is clearly evident in the work of Tracy, Hutchinson and colleagues who outline the reflection is in principle a narrative activity (Tracey et al., 2014, Hutchinson and Tracey, 2015, Tracey and Hutchinson, 2016), where events and circumstances, involving thinking subjects engaged in actions, often with objects, at some place in time are under scrutiny, as the reflective student attempts to make meaning from their experiences. I adopt this perspective on reflection, and discuss this important relationship to narrative, in the next section of this literature review.

2.2.3 Narrative

I have outlined above the nature of the design project, the context in which our thesis inquiry takes place, as the establishment of plans of action and concretisation of goals, in accordance with the paradigm of design as a social practice. The premise of reflective activity as a key competency was discussed and differentiated within the literature, seeing reflecting-in-action (Schön, 1983, Kolb, 1984) being better aligned to problem-oriented approaches to design practice, with reflecting on actions (Boud et al., 1985, Mezirow, 1998) more aligned to project-oriented approaches. Outputs associated with fostering reflective practice can take many
forms, texts and journals being a primary one in the educational context. More specifically, accounts of project activities can include reports, exhibitions, presentations, and other textual constructions that, in the product design context, help to frame the story of the process which has led to the presented artifact creation. Within creative disciplines, these can often in multimedia format, combining objects, images and texts to communicate the overall project process and outcome. These accounts are often compiled at the conclusion of the project, using a summary of insights, actions, and outcomes which provide the basis of the project story or narrative. In this section, I discuss these communicative perspectives and devices, highlighting structures and constituent parts of project stories and narratives which contribute to shaping the design project, and their relationship to reflecting on actions.

Beyond the interest in reflective accounts of designers engaged in reflecting-in-action, or the reflective texts of students learning to design through problem or project based approaches, a growing space for understanding the conversational aspects of design has emerged in recent years. This "linguistic turn" is highlighted by various scholars embracing linguistics, sociolinguistics, conversation analysis and other forms of interactional communication (Fleming, 1998, Luck, 2003, Dearden, 2006, Dong, 2007, Luck, 2007, Glock, 2009, McDonnell, 2009, Oak, 2011, Adams et al., 2016a, Lloyd and Oak, 2018). Most of these studies emphasize the ethnomethodological position surrounding discourse and the performativity of talk-in-action. When talk corresponds to the practice of reflective activity, the examination is often situated in the educational context, resulting in the discussion of reflective writing, coaching reviews or public critiques of student work (Adams et al., 2003, Adams et al., 2016a, Baaki et al., 2016).

Such studies have provided significant insight into the relevance of designer’s conversations relating internal thoughts and external representations in the moment, but remain situated within a constrained design space, nominally examining responses to "the design brief". For
the most part, they do not provide longitudinal accounts of conversational interactions across
temporally extended, situationally displaced, multiple stakeholder design project. Longitudinal studies of designers in action, examined through ethnographic accounts across
time and place, are most often situated in work-based studies related to science and technology
2009a, Wilkie, 2010) and place strong emphasis on the social aspects of design practices and
processes over time.

Strands of design research which have adopted a language based approach to the
phenomenological examination of design as a social practice shares much with the STS agenda,
particularly in challenging disciplinary boundaries (Gieryn, 1983) and perceptions of technical
situated design goals as “interpretative flexibility”, drawing from Pinch & Bijker (1984), and
also from Star (Star et al., 1989, Star and Griesemer, 1989). Star herself is critical of the
implementation of the concept primarily used for shared understanding about things, in lieu of
understanding how boundary objects act in contexts to facilitate moving between ill and well-
structured circumstances as well as establish information regarding work (Leigh Star, 2010),
overlooking critical aspects of negotiation and trajectories associated with the concept.

This study, with an emphasis on the product design project, aims to examine more than
products developed as part of a co-evolving problem-solution space (Dorst and Cross, 2001),
but also go beyond the examination of accounts of design through the performativity of
designers’ talk as a part of a communicative exchange (Dong, 2007, Luck, 2009). Rather, this
study understands products, prototypes and other artifacts as specific forms of text, when
understood in the broadest sense (Hodge and Kress, 1995, Kress, 2010). Texts are carriers of
information, disseminating the stories and narratives of the project. Product design outcomes
can understood as texts which are intended to be adopted by others, fostering future experiences
through interaction, when read as artifacts which correspond to people’s personal systems of value. Crilly (2008a, 2008b, 2010) argues that adopting this approach aligns us to social semiotic models of communication, and this may require some consideration about what designers are reflecting upon in the creation of artifacts, stories, accounts and narratives as part of the project, establishing forms of situated conversations and experiences with others through artifacts, expanding our views regarding the relationship between thought and communication. Crilly explains:

...Eco rejects the basic sender - message - receiver models arguing that ‘what one calls a message is usually a text, that is, a network of different messages depending on different codes and working at different levels of signification’ (Eco, 1979: p 5; also see Eco, 1976: p 141). Consequently, different people will construct different meanings from the same message depending on their experiences, values, motivations and capabilities (Crilly et al., 2008a).

To do this, some discussion about narratives would be useful. First, a definition of narrative is provided, highlighting seminal work from the field of narratology. Second, the structure of narrative is highlighted, and finally, this is tied back to design research and our initial citation analysis to outline how narrative has been examined in understood in relation to design practices, nominally through a method in early data collection about user experiences, or as an approach to output through modes of reflection. This section concludes by highlighting that narratives are also widely understood as constructions themselves, where we ask to what extent the narratives and stories of the design project itself is designed, and how the objects and outputs of product design development fit into this frame of our examination.

Catherine Riessman provides a definition of narrative as:

The term “narrative” contains many meaning and is used in a variety of ways by different disciplines, often synonymously with “story.” I caution readers not to expect a simple, clear definition of narrative here that can cover all applications ...
Briefly, in everyday oral storytelling, a speaker connects events into a sequence that is consequential for later action and for the meanings the speaker wants listeners to take away from the story. Events perceived by the speaker as important are selected, organised, connected and evaluated as meaningful for a particular audience (Riessman, 2008).

Halliday (2014) outlines that narrative can be understood as a manner of dealing with the "outer" experiences of human life; notably human events and human actions understood through organising structures of entities, processes and qualities of which the narrative clause is composed. Entities are nouns, (peoples, places and things); qualities are adverbs and adjectives and provide evaluative insights; and processes are verbs, highlighting three types of action (doing/happening; sensing/saying; being/having).

Polkinghorne, in establishing a premise that narrative is a form of communication which primarily stems from narrative knowing, suggests that narrative is:

...for organising experience into stories. The process of seeing human actions as meaningful in sequences of events linked together in a causal chain requires cognitive skill, judgement and the application of previous experiences. When the story-making process is successful, it provides a coherent and plausible account of how and why something has happened. (Polkinghorne, 1988)

Bruner echoes Polkinghorne when suggesting that there are two primary modes of thinking and world-making: the logico-scientific mode, and the narrative mode. These modes support each other, particularly where gaps in understanding or lack of insights are apparent, that is, logical truth is lacking:

...we organize our experience and our memory of human happenings mainly in the form of narrative - stories, excuses, myths, reasons for doing and not doing, and so on. Narrative is a conventional form, transmitted culturally and constrained by each individual's level of mastery and by his conglomerate of prosthetic devices, colleagues, and mentors. Unlike the constructions generated by logical and scientific procedures that can be weeded out by falsification, narrative constructions can only achieve
"verisimilitude." Narratives, then, are a version of reality whose acceptability is governed by convention and "narrative necessity" rather than by empirical verification and logical requiredness. (Bruner, 1991)

There is often confusion about the term narrative and conflation with the commensurate term story. They share many characteristics, particularly a common structure predicated on a sequence of events, temporally organised. Both have a narrator, or the teller of the story, and both are communicative devices aimed at conveying expressing experiences of events which have already occurred. The key distinction in this thesis outlines that a story remains a selection of events, whereas a narrative is a particular set of events, selected for a purpose by a narrator, in order to convey a particular meaning, predicated on a particular point of view. This corresponds to Riessman’s definition earlier in the chapter, and is the definition to which we will refer for the duration of the thesis.

As we’ve seen, narratives are constructed from assorted clauses, representing events, linked temporally. But what is an event? Similar to Labov, the Cambridge online dictionary provides a simple definition of the event, as follows:

"anything that happens, especially something important or unusual"

This definition doesn’t help remove the lack of clarity that Riessman warns us about, since the definition seems to encapsulate almost everything. A narrative event as outlined above may involve something happening, centred upon action.

Events are clauses within narrative formats that involve accounts of activity, where and when something happens. At its most basic level, it involves a subject engaged in action, and can contain as few as two parts of speech — a noun and a verb. In this form, the verb is intransitive, describing an action which does not involve an association or relation to a direct object. The action is directed at the subject itself. By comparison, transitive verbs involve direct objects in

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relationship with the subject where actions are in some way being transferred between subject and object. Transitive verbs are more easily identified by the relationship to another externalised object. In short, transitive verbs direct the subject’s actions toward something else. Events are relatively straightforward, involving agents engaged in action, often with other objects, situated in some time and place. These 5 components are understood to comprise a basic event sequence. The three main constituents (subject, action and object) as well as the often inferred constituents of time and place, are illustrated below in Figure 8.

Figure 8: Event Triple, in time-space

Todorov (1969) deduces this basic structural schematic of a narrative through examination of examples from Boccaccio’s *Decameron*. In his analysis, he works across a number of examples and posits that a common minimum structure of the plotline is available, and is easily evident in the basic unit of a clause, which consists of two main parts, understood through to parts-of-speech within texts: a) agents and actors, identifiable through proper nouns, and b) actions, identifiable through verbs. The core of the narrative, however, isn’t just an assembly of events, but are necessarily assembled from particular sets of events, highlighting that some infringement, violation, or surprise has taken place. From a methodological perspective, the analysis of narrative allows the researcher to understand how speakers and writers construct and assemble sequences of events in order to construct meaning, with special emphasis on how narrators place emphasis on "the particular" (Riessman, 2008), the particular here being
something special, unique, or different which is understood by the narrator to be necessary to share through his accounts of action.

As with Todorov, William Labov outlines that narrative is structured around a series of clauses which outline actions and events that are temporally connected. However, this isn’t enough to make something a narrative or story worth telling, according to Labov. In his grammar of narratives of experience, he suggests that narrative accounts contain what he refers to as a “complicating action” (Labov, 1972). This complicating action corresponds to Riessman’s notion of the particular, and Todorov’s notion of infringement. It would also seem to roughly correspond to Dewey’s ambiguity or doubt as a precursor to reflecting on experiences, and Schön’s notion of the grounds for reflecting-in-action whereby there is a “break in the smooth flow of action”. In short, according to Labov, narratives result because “…something happens” (Labov, 1972).

Labov’s grammar outlines 6 different types of clauses within an overall narrative grammar, derived on oral accounts of inner-city experiences amongst youth of New York. Clauses, suggests Labov, are references to events which have taken place in the past, and are sequentially structured by a narrator in the construction of the narrative about that experience.

The 6 point narrative grammar from Labov:

- Abstract
- Orientation
- Complicating Action
- Evaluation
- Result/Resolution
- Coda

Halliday suggests that narratives and their constituent events are intended to describe processes of action, and that these active verbs can take three primary forms: being (or having); sensing and doing. These reflect the types of experiences of processes and events that people often
recall within narratives, which according to Labov constitutes inner experiences (sensing) or outer experiences (doing). It should become clear that not every utterance or statement someone makes is necessarily a narrative event. Some statements are simply propositional and provide descriptions about the nature of things in the world, while others provide for evaluation and judgement about feelings and beliefs that the agent holds. Such statements, though a subject and a verb are clearly present, adhere to a form of the narrative clause that is more ontological, where subjects are identified as a particular member of larger category, possessing attributes which help differentiate between community members and characterisation.

Narratology is a distinct discipline and narrative analysis a useful methodological approach to the study of experience reflected upon, but for the purposes of this dissertation, the examination of projects and their narratives is situated in design practices, namely product design. To this extent, a review of the relevant literature is undertaken in this section to see how it compares to the wider scholarship, and how narrative is understood and employed more specifically in the design research community.

Earlier, in the design research review on literature associated with reflection, a number of papers were already outlined which highlighted narrative (and stories) as outcomes of the design process. Calvo (2017) and Sunday (2018) describe situated drawing as things to reflect upon as shorthand, whilst constructing narratives downstream of the actual inquiry process engaged. Tracey & Hutchison (2016), and Kurt & Kurt (2017) facilitated students’ creations of journals to foster metacognition about their own practice, whereas McDonnell et al employed the media of video when having students construct stories in order to reflect on their own experiences (2004). In these instances already described, concretised artifacts are triggers for reflection, but ultimately also are vessels of experience, albeit employed more as tools for designers to reflect upon themselves. The actual projects of design that the researchers or
students are engaged in whilst these tools are being developed seem less important than the narratives of design experience being fostered in the designers themselves.

Narratives and stories are also employed as methodological toolkit from which designers can draw insights. Blaylock (2003) provides accounts from professional architects who employ narratives as part of their project development, as a method for exploration and idea generation. Kankainen et al (2012) discuss their co-design method called Storytelling Group which is employed in service design practice to allow a participatory process with service users to “tell their stories” based on real-world experiences. Childs et al. (2013) present a similar perspective to narrative as Blaylock, from an engineering design perspective in the educational context. Narratives are fostered amongst students in order to ensure the ideas of students remain practical and realisable during design development. Lloyd & Oak (2018) discuss how stories emerge from within two co-creation workshops, where participant placements have an impact on the nature of stories being told within the workshops, and impacting on subsequent design. The role of narrative both as a source of knowledge, but also as a method of engagement, are introduced, but the impact of different narratives, taking place across sets of participants who hold different values, is unique to this paper, where different understandings and perceptions of the narratives of others is explored. Celikoglu provides two papers which discuss design and narratives as method, both situated in ethnographic encounters. The first paper examines the elicitation of user stories through interaction with cultural probes (2017) as a basis for a method which designers can infer user meaning, and the second being an extension of the first, involving discussions with the designers and the narratives to hand, ascertaining exactly how designers made meaning out of the narratives of others (2019).

In all these instances, narrative would appear as something outside the design process itself, employed by designers as an approach to derive meaning from situations experienced by others. Narratives are ways in which meaning and knowledge are transferred across people,
space and time, and carry information about the actions that people are engaged in. Narrative, in these studies it seems, contain meaning of experience, which must be translated and codified by the designer in logically deducting (inducting, abducting) what next steps need to be taken for the process to continue.

Despite this strong affinity to understanding narratives as communicative techniques intended to convey meaning, and employed as content knowledge from user experience by designers in order to understand what steps need to be taken in relation to project development, a few studies go further in declaring that design itself is a practice of narrative, implying what Polkinghorne (1988) and Bruner (1986, 1991) have already suggested, that narrative is more than an artifact that contains knowledge, rather it is also a way of thinking about the worlds in which we live. Dillon & Howe (2003) present a critical analysis of design education in the UK emphasising a positivist approach to object generation at the expense of a constructivist one, where designers make objects that are read, and reveal meaning to those engaged with objects, through the stories they tell. They draw a loose parallel between designers and writers, both who are engaged with conveying stories enabling people to construct meaning, as readers and audiences. For these authors, the emphasis is less on the plans of actions involved in designing that involves the construction of stories, rather how objects themselves are read, like texts. In this way, there is some conflation between their articulations of “design”, when they are primarily making reference to design outcomes.

Bleeker (2009) presents an object perspective from the disciplinary position of HCI, outlining that constructed, technical artifacts operate as props and points for discussion in their materialisation, which he refers to as “design fictions”:

*Design fiction is a mix of science fact, design and science fiction. It is a kind of authoring practice that recombines the traditions of writing and*
Both Dillon and Bleeker are strongly suggesting that “objects tell stories”, and this certainly fits within contemporary approaches to Science and Technology Studies (STS), where objects possess agency themselves and are influential in the driving the course of human action. Inscription devices (Latour and Woolgar, 1979, Latour, 1987); boundary objects (Star et al., 1989, Star and Griesemer, 1989); conscription devices (Henderson, 1991); and intermediary objects (Vinck and Jeantet, 1995, Vinck, 2012) are all material manifestations of things in object worlds (Bucciarelli, 1994, Bucciarelli, 2002), and these scholars have clearly shown the different ways that objects and people working with those objects interact, and impact each other. But none of the STS literature implicates objects as “articulating narratives”, and here we are wise to follow Tim Ingold (2013) in his discussion of telling, in critique of Polanyi’s summary of tacit knowing being “more than we can tell” (Polanyi, 1958). Ingold highlights that Polanyi may be conflating telling with saying (articulating), in that saying or articulating involves a narrator, whilst telling involves readership. With this in mind, we interpret that both Dillon and Bleeker are suggesting that objects are texts to be read, not narrators that are able to articulate and narrate experiences of past events.

Seeing design outputs as texts, whether sketches, drawings, prototypes, models or event predecessor artifacts (Morch, 2013) suggests that design activity might be viewed through various lenses involving communicative action, linguistic structures, or narrative forms — McDonnell, Lloyd & Valkenburg (2004); Tracey & Hutchison (2016), and Sunday (2018) outline approaches to where reflecting-in-action is understood through the lens of narrative, particularly in the construction of narratives which articulate personal values, and systems of beliefs. Elsewhere in design research literature, Crilly presents 5 distinct perspectives where products are understood as communicative devices (Crilly et al., 2008a); Lloyd presents an
overview of design activity being subjected to post-modern analysis, invoking the metaphor of "design as text" (Lloyd and Deasley, 1998); Strickfaden & Heylighen present work on design educators interpreting the design process, framing their data as "...largely stories or narratives..." (Strickfaden and Heylighen, 2010); Dillon & Howe are more explicit in their direct framing of "design as narrative" (Dillon and Howe, 2003). Dong and colleagues have done extensive work on understanding design as enacted through language (Dong, 2007); design and language in relation to the sociology of knowledge (Carvalho et al., 2009) and evidencing design cognition through language (Dong, 2005, Dong et al., 2013).

In this literature involving narrative and design, the structure of narrative is clearly understood, involving accounts of agents engaged in actions, where the narrative is an attempt to articulate an interpretation of the meaning of the actions, in a specified place and time. In some instances, the objects are a component of the story (inter-actions), and in some instances, the objects are central to the story itself, more akin to the subject of the account, told from a third-person point of view. But in this way, where the emphasis is building stories associated with design objects, there seems to be some detachment from design and the narratives themselves: the narratives are a form of account of the design process; a repository of data about user perception and past experience; a trigger to elicit stories by people to understand how they make sense and meaning of material things. But what if there were a simpler approach, one where narrative weren’t secondary to meaning and knowledge itself, but where narrative WAS meaning and knowledge, in the way that Bruner (1986, 1991) and Polkinghorne (1988) suggest. Is there another way in which we might understand the relationship between design and narratives? Before fully addressing this question, the next section outlines one further important feature of narratives, beyond their structure — rather, providing a reason why they emerge and exist in the first place.
2.2.4 Difference – more than one

Up to this point in the literature review I have discussed projects, in lieu of problems, as sites of inquiry and examination through plans and actions. Reflection was raised as a key competency in designing, but beyond experience, what exactly is being reflected upon was not wholly clear. Dewey suggests reflective thinking is prompted by doubt, uncertainty, or ambiguity, Schön describes the prompt as surprise. Everyone generally agrees that reflection is predicated on the examination of experiences as a source of insight, towards learning about potential actions in circumstances where the surprise has been generated. Reflection is fostered, examined and understood through articulation and communication shared with others, and often takes the form of narratives, situated in the particular, based in texts when defined in the broadest sense of things able to be read. At this juncture, we ask not how, but why these texts need to be generated, and the nature of the doubt, uncertainty or surprise that drives reflection within the project of design. In this section, I suggest that this doubt is regarding some aspect of difference between things under examination. Difference is a complex concept, and my statement will require some clarification. Difference might be a mathematical term; it is also understood in as a term of comparison between two things that are not similar. In relation to our thesis, difference is also a key concept in language, text and communication when understood through semiotic practice, which is how we start this next section of our thematic literature review.

The literature review began as an extension of the work in our introduction and motivations, outline in Chapter 1. The search of the literature was thematically oriented, looking at the specific set of relating to design, project, reflection and narrative. It is fair to ask why difference was not part of this search term, and why this concept is being introduced now. I’d like to
argue that this concept has been here all along, only it hasn’t been explicitly articulated, until now.

The Oxford English online dictionary defines difference\(^5\) as the following:

1. a. The condition, quality, or fact of being different; dissimilarity; an instance of this.
   b. A particular way in which two or more things differ; a point of dissimilarity.
2. A distinction made between two or more things.
3. A disagreement of opinion or sentiment; a dispute or quarrel, (in early use) esp. one involving open hostility or violent conflict. Now chiefly in pl.
4. a. The amount by which two quantities differ from one another; the remainder left after subtracting one number from another.
   b. The amount by which the value of a financial asset, such as a stock or bond, has increased or decreased over a given period of time. Frequently in to pay the difference.
   c. Math. A finite difference (finite difference at finite adj. 3); (in early use) esp. the difference between two adjacent terms in a sequence of numbers.
5. a. A distinguishing characteristic, feature, or quality. Obs.
   b. A division, class, or kind; a genus. Obs.
   c. Heraldry. An alteration or addition to a coat of arms, used to distinguish a junior member or branch of a family from the chief line.
   d. Philos. and Logic. A characteristic or feature distinguishing a species or thing from all others of the same genus or class, as used for the purpose of defining that species or thing; = differentia n. Also more fully specific difference.

This definition suggests that difference involves a particular way in which distinctions are made, or present themselves, between two or more things. Difference highlights the presence of a division or boundary (class, kind, genus, type), but does not necessarily specify what the boundary is. This suggests that two things can be different (i.e. difference in type; categorically dissimilar), or that some quality, attribute or measure is being used to determine difference between things (i.e. difference in degree of dissimilarity). An example might be a relative comparison between apples and oranges; they are examples of different types of fruit, but as

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fruits, there is a degree of difference in how sweet each of them are. The relativity of difference becomes amplified when a context is provided which frames the situation — perhaps the comparison involves the way in which the fruit is eaten, but we might equally talk about which fruit is best with which to bake a pie.

How does this concept of difference appear within the literature already reviewed, relevant to this thesis? Projects were discussed as a form of temporary organisation, outlining sequences and plans of action, leading to a goal state. Difference is implied between the current state, which is different in some way from the goal state. Regarding reflection, Dewey outlined a doubt, uncertainty or ambiguity as it’s trigger; Schön simply suggested that reflection involved some “surprise”. What is implied, simply put, is that a difference exists, between what is expected to happen, and what actually happens, leading to reflection (whether active or passive). With respect to narratives, Riessman refers to narratives as examples of “particulars”, outlining that the reason for a narrative to exist has to do with it providing some specific aspect of experience which is important, or different, to the many other experiences which are not recounted. This becomes evident in the design research literature that involves designers’ examining user-driven narratives as insights to building new ones; designers’ reflecting on their own practice to understand in a different way; or students reviewing videos of their own practice to foster reflection and identity construction as they learn the difference between being a student designer, and a professional.

Difference is sometimes understood in arithmetic terms as the remaining value when two other numerical values undergo the operation of subtraction. Difference, more widely, is a concept regarding relations and distinctions between signs, and finds employment in the structuralist (and post-structuralist) approach to language.
Though the concept of difference as an antonym of sameness is likely much older, the introduction of the term into critical theory is generally associated with Ferdinand de Saussure in his structuralist approach to linguistics:

In the language itself, there are only differences. Even more important than that is the fact that, although in general a difference presupposes positive terms between which the difference holds, in a language there are only differences, and no positive terms. (Saussure, 1960)

Saussure’s work in structuralist linguistics gave rise to the discipline of semiotics and signification: a system of signification constructed from signifiers and signifieds. Following from Jakobson (2010), signs in the language system gain their meaning, according to Saussure, based on two types of structural relationships: syntagmatic (position and order) and paradigmatic (choice and substitution). In a simple sentence, syntagmatic relations are the word ordering and operate in accordance with other signifiers intratextually (in the sentence), whereas paradigmatic relations are those which reference things intertextually; that is, those signs absent from the text (Saussure, 1960). Figure 9 below illustrates the two relationships along axial lines, in reference to the corresponding stock image.

A statement describing the scene might be the man walking down the road. The syntagmatic relations construct a meaning through a particular order (though grammatically correct, the
road walking down the man is grammatically correct, but is understood as nonsensical due to incorrect allocation of subject/object ordering). Paradigmatically, however, choices are possible which construct different meanings and different understandings. Man is a particular reference to the person’s type, through membership of gender. This type membership is understood primarily through a contrast to woman, even though one is not present. Another paradigmatic choice might be musician, in place of man, who we see walking down the road, the implication of type membership related to the possession of a particular skill or aptitude in using the device he appears to be carrying, separating him from those who do not possess such competencies.

The example, as described above, only provides a descriptive account of the image as an individual might think about it, but difference only emerges when the language system is invoked. To write, or speak, the various sentences implies a communicative action involving an other; a listener, or an audience. A new difference emerges, between the relation between the utterance (itself a signifier) and the image. To what extent does the listener interpret the same relations in the system? Conversationally, through turn-taking, a response would be expected either confirming, denying or clarifying that the message was received and understood as intended. These points outline a pragmatic perspective on systems of difference in language and semiotics construction, where language is understood to operate through particular structures, but operates also as a type of action which conveys and constructs meaning across collectives, and socially shared. Conversations between people, are one particular example of language-in-action, where communication is understood beyond simple information exchange. When Schön invokes the metaphor of a conversation in describing situated design practice with sets of materials, he appears to be suggesting this pragmatic perspective, and gives agency to the materials in the situation.
A full and detailed account of semiotics, linguistics, pragmatics and associated theories are beyond the scope of this literature review. In regards to semiotics, useful introductory texts to recommend include Sebeok (2001) or Chandler (2007). For an outline of the discipline of pragmatics, see Mey (2001). For an introduction to ways language is operative, the work of Austin (1970) or Searle (1979) is suggested. A discussion about conversation, inter-personal dynamics and social construction would benefit from further reading of Sacks (1995) or Grice (1989). Relevant for this thesis, however, is understanding the relevance of language, semiotics, and difference in the realm of design research.

Following structuralism, a number of philosophers (notably French) argued that it was necessarily reductive to view and understand the world (and language) through pre-established structures. For these post-structuralists, the driving question was where these structures came from in the first place, and in that sense, structuralism, they felt, was inadequate in providing a response. Post-structuralism, very generally, argued that the structures themselves were socially made, and most often through the application and usage of text and language, which was not perceived as being neutral, and meaning not embedded. Though a wider discussion of post-structural thought and its relationship to language is beyond the scope and energy of this particular thesis, it is worth acknowledging that the work of Jacques Derrida and Gilles Deleuze has placed significant emphasis on deconstructing language, text and social structures, leading a call to celebrate difference as a primary concept, before identity, and, more widely. As a philosophy in its own right:

...such would be the nature of a Copernican revolution which opens up the possibility of difference having its own concept, rather than being maintained under the domination of a concept in general already understood is identical (Deleuze, 2014).
To emancipate the concept of difference, allowing it to become a philosophy in itself, there are 4 principles which must be challenged, suggests Deleuze, which keep our thinking about difference as a secondary concept subjugated, or mediated:

There are four principal aspects to “reason” insofar as it [difference] is the medium of representation: identity, in the form of the undetermined concept; analogy, in the relation between ultimate determinable concepts; opposition, in the relation between determinations within concepts; resemblance, in the determined object of the concept itself... difference is “mediated” to the extent that it is subjected to the fourfold root of identity, opposition, analogy and resemblance (Deleuze, 2014)

For Deleuze, these 4 principles are not difference themselves, but are employed as obstructions of difference, which he understands as an underlying, primary concept which reveals the truest nature of the world as it is, purely heterogenous. As we try to understand the world around us, we employ ‘reason’ (his braces) as a method which mediates pure difference in 4 ways, through constructing:

• an identity relation, when there is no determined concept frame yet available;
• an analogy relation, between two determinable concept frames in order to understand one, in terms of the other;
• an opponent relation, between two things within the same concept frame, outlining the varying degree of concept determinations available between them
• a resemblance relation, providing the degree of correspondence between the thing determined and its determinable concept frame

Deleuze’s work is necessarily complex, as he employs terminology which is highly specific to his critique to the philosophical project. Within his framing of principles, he employs the terms “determinable” and “determinates”, by which I loosely translate as:

• Determinable – a concept frame and its associated attributes
• Determinate – an object, an exemplar of the concept in the world, and its properties

The interested reader can review the discussion of determinates and determinables from the Stanford Encyclopedia of Philosophy, which was accessed on Dec 1 2020 in order to construct this simplified summary of the topic, first introduced by JOHNSON, W. E. 1921. Logic, Cambridge., The University Press.
As outlined earlier, a full explanation of work of the post-structuralists is beyond the scope of this dissertation. The discussion of difference and the very brief introduction to Deleuze, however, is intended to highlight a critical perspective of difference, between thought and language, which highlights more than ontological categorisations, and binary relationships between thoughts and things. Rather, what Deleuze implicates in his 4 principles of reason which camouflage difference is that the manifestation of difference requires us to consider how to make sense of the totality of things, through actively constructing relationships between things in the world and our thinking about them, whether we consider relations about relations of type (identification; analogy), or relations of degree (opposition; resemblance). Difference, for Deleuze, is the foundation on which our understanding of the world is actively constructed, continually becoming.

Though not directly aligned to the premise of difference underly Deleuze’s thinking, there are other many other scholars who have adopted a strong position regarding the continual social construction of the world and our understanding of it, namely in the Philosophy of Science, and Science and Technology Studies (STS). Works involve the introduction of concepts such as paradigm shift (Kuhn, 1962); demarcation (Gieryn, 1983), boundary work (Star et al., 1989, Star and Griesemer, 1989, Leigh Star, 2010); classification and categorisation (Bowker and Star, 1999), and mediation (Latour, 1987, Vinck and Jeantet, 1995). STS perspectives have also found their way into design research, through scholars such as Bucciarelli (1988, 1994, 2002), discussing social aspects of design through discursive practices of “constraining, naming and deciding” during engineering design; Minneman (1991, 1993) outlining social practices of engineers such as local negotiations, and the acts of preserving ambiguity, avoiding demarcation; Yaneva (2009b) as well as Storni (2015) in translating Latour’s Actor-Network Theory into design practice; and Wilkie (2010), providing a perspective of design practice through a conception of “user assemblages”. These thinkers, amongst others, view language,
text, and discursive actions as more than information or knowledge exchange; critically, they suggest that language acts themselves are a supplemental approach to shaping and understanding the world as we know and understand it, through naming and renaming and operations of (dis)placement (Buchanan, 1992, Farias and Wilkie, 2016). This perspective of discourse and design underlines our social framing of design practices, and our examination of projects, reflection and narrative outcomes, particularly through the manifestations of difference. The following section returns to discourse, text and the use of language as the system of difference, and how it has been understood and examined in relation to design practice.

In the previous section, I introduced the notion that narratives, as one form of text, arise because of difference, since language operates through a system of difference. Difference was described as the foundation on which our understanding and explication of the world unfolds, through constructing relations between types, attributes and degrees of presence/absence of these attributes. This unfolding is rooted in language, not as a communication medium alone, but as a way of constructing meaning, through language. Crilly et al explains:

...Eco rejects the basic sender - message - receiver models arguing that ‘what one calls a message is usually a text, that is, a network of different messages depending on different codes and working at different levels of signification’ (Eco, 1979: p 5; also see Eco, 1976: p 141). Consequently, different people will construct different meanings from the same message depending on their experiences, values, motivations and capabilities (Crilly et al., 2008a).

In this closing section on difference, as part of the literature review, I return to design research scholars who have touched upon aspects of language, particularly from a semiotic perspective, where language and specifically talk, is employed as a manner of shaping positions and conveying perceptions.
Fleming (1998) presents an early study highlighting the everyday practices of inter-personal communication within design practice, prefacing that these conversational exchanges in the studio have (up to that point in time) been relatively ignored:

...mundane, day-to-day activity that occurs during actual design projects - activity irreducible to planning or form-giving – is largely disregarded (Fleming, 1998).

Since Fleming, design researchers have been investigating the nature of talk and discourse as a key aspect of the social nature of design activity, and insights have been steadily expanding. Many of the researchers draw explicitly from alternative perspectives of talk, examining approaches to design when seen as identity and roles formation (Oak, 2001, Adams et al., 2009, Tracey and Hutchinson, 2016), argumentation (Stumpf and McDonnell, 2002), participation and collaboration (Luck, 2003, Luck, 2007, Heinemann et al., 2012), and negotiation, managing disagreement and interactive production (McDonnell, 2009, Luck, 2009, McDonnell, 2012, Oak, 2012). Studies outline a variety of employed techniques and methods to understanding talk-in-action, including conversation analysis (Glock, 2009, Oak, 2011, Matthews and Heinemann, 2012), latent semantic analysis (Dong, 2005, Yang et al., 2009) and, as outlined earlier, narrative analysis (Lloyd, 2000, Dillon and Howe, 2003, Strickfaden and Heylighen, 2010, Lloyd and Oak, 2018). Though most of these papers are examining how talk and language is employed within design practice to help shape it, none of these papers explicitly discuss the relationship between language, talk, conversation, and difference.

When considering conversation, language and text in a social context, placing emphasis on how language is used by people to create social structures, rather than the structures themselves leads us to the socio-linguistic perspective, emphasizing inter-action in language systems as a requirement for the making of meaning. Kress (1989a, 1989b, 1992) stresses that language, particularly verbal and textual discourses, provides insight into difference, making it apparent:
...difference is the motor that produces texts. Every text arises out of a particular problematic. Texts are therefore manifestations of discourses and the meaning of discourses, and the sites of attempts to resolve particular problems...

Dialogues, whether conversations, interviews, or debates, are the clearest examples. In their structure they display discursive difference at every point. Where there is no difference, no text comes into being. (Kress, 1989a).

Kress outlines that text results when difference arises (Kress, 1989a), as a result of a particular problematic. Text is referred to in the broadest possible sense. Earlier, I outlined how objects, drawings, plans and other physical artifacts, generated within design projects, are also types of texts available to be read, referenced directly in the production of project narratives. Reflection, I outlined, involves considering the relationship between action and outcome (past or present) and as mentioned, is considered a key competency of effective design practice, in delivering project goals. At the start of this section on difference, we began with the question of what is being reflected upon. If reflection is understood as an ambiguity, doubt, uncertainty, or “element of surprise” I argue that this position of comparison, between two states of past and present, has allowed difference to manifest, in Deleuzian terms. For Schön, reflection was about “a break in the flow of action”, and even this requires us to understand two states of action, namely, our concept of the expected flow of action, which no longer has a relation of resemblance to our current situation. Simply put, I suggest that what is being addressed and reflected upon in design projects is difference, resulting in the construction of the narrative to explain, and manage, this difference.

Currie outlines that difference is not only important to studies of language, but has implications in a great number of disciplines:

The concept of difference is unusual among critical terms. While others come and go, difference has persisted. While others are confined to some particular critical perspective or approach, difference has found applications
in almost every branch of literary studies, and perhaps more significantly, beyond the domain ... (Currie, 2004).

Two examples beyond the domain of literary studies, feminist critical theory, or philosophy are seen in organisational management (Cilliers, 2010), and design (Law, 2002, Earl et al., 2005).

Cilliers’ discussion of difference, in the domain of business and management situates the concept in relation to organisational complexity, where complexity is understood as the difficulty in making sense or structure due to the of heterogeneity found in the world. Cilliers contends that a homogenous organisation may be stable, reliable and predictable, but ultimately unable to respond to the real world, one which is dynamic, fluid and diverse:

The problem to be addressed should now begin to emerge. For an organisation to have vital and dynamic properties, it needs a lot of diversity. If, however, we want to describe, understand, control or manage such an organisation, the diversity becomes a problem. We cannot reduce rich, nonlinear difference to simple descriptions, but we need descriptions nonetheless. (Cilliers, 2010)

Complexity as heterogeneity and difference is also discussed by Law, notably in how knowledge moves and operates within complex systems, such as the design and development of a wing for a military jet-fighter:

This wing, and the formalism from the English Electric brochure, have much to tell us about complexities, ... of that which is not pure or clear or homogenous but rather carries what is different within. I will think of these as the complexities of heterogeneity.

The tools that I will use to think about this derive from semiotics. A reminder: semiotics is the study of relations. More specifically, it is the argument that terms, objects, entities, are formed in difference between one another. The argument is that they don’t have essential attributes but instead achieve their significance in terms of their relations, relations of difference. (Law, 2002)
One of the few design research papers explicitly discussing difference and its relationship to design comes from Russell (2002). There, he argues that design and difference are intimately connected to the philosophy of phenomenology, which encompasses much of our everyday lives when we are attuned to the world. Design, he argues, is a process of mediation, where material is integral to the process, and design involves the discrimination of particular materials to communicate mediation, based on difference and our attenuation to it. His paper begins with outlining the prevalent operation of difference in the simplest of pleasures, collecting stones at the beach:

Occasionally we fix our attention on one stone in particular and we pick it up. In selecting this particular stone we are inventing, or 'coming upon'. Mostly the find is trivial, of the moment. Now and then we find a piece that we take home for its smoothness, roundness, colouration, markings, mass or something else that takes our fancy. Such is the phenomenology of difference in our everyday lives. We discriminate rocks from stones and stones from pebbles and pebbles from grains of sand. We are attracted to the differences of our own attention. Should we come upon a fossil, our learned minds are drawn with a different, educated order of fascination. Here then are rocks that are not rocks but rather the mineralized remains of what once were plants or animals. We see something that is altogether anachronistic, of another world and another time. Now we have discovered something that transcends the differences of our immediate attention through its own ordered differences: through its markings, the stone can be read...

The simple observation of difference, of this pebble and that stick, is, in itself, not a matter of complexity. Complexity is introduced by the subsequent observation that this stick is different in a way that will allow for the changing of my environment through the stick's mediating of my desire to change the environment (Russell, 2002).

Russell alludes to the complexity of the stick, not in differential opposition to the stone, but in how we begin to understand how the stick, as an intermediary, might be applied in modifying and addressing a desired change in the environment. Bleeker, whom we met when discussing
design fictions, uses a contemporary trope regarding the practice of design, to explain the notion that design, ultimately, is somehow about difference:

*Design allows you to use your imagination and creativity explicitly. Think as a designer thinks. Be different and think different. Make new, unexpected things come to life. Tell new stories. Reveal new experiences, new social practices, or that reflect upon today to contemplate innovative, new, habitable futures. Toss out the bland, routine, “proprietary” processes. Take some new assumptions for a walk. Try on a different set of specifications, goals and principles (Bleeker, 2009).*

Bleeker suggests that design brings about something new, something different. But, how does it come about? Designing “something new” involves a practice of identifying something (naming, labelling, referencing), supported through the bring forth some other thing which opposes it, in order to support that identity — that is, we understand “the new” only by bringing forth “the old”. In Deleuzian terms, this is a falsehood, since the binary relation between old and new is contextually constructed. Another binary relation might be “new” and “used”, implicating some further aspect involving presence and absence of utility, as opposed presence/absence of temporal passing. In this overly simplified example, we being to see the complexity and heterogeneity discussed by Law and Cilliers emerge, and contend that designers involved in “making new” are engaged in examining difference, as they move and transition from “old”, “used”, or otherwise, toward their conception of “new”. The notion that design projects result in things is an unhelpful truism, I contend, and that projects are actually transitions between things, involving manifestation and management of difference. In concluding this section, the transitions in projects are noted through the textual production that witnesses and documents those transitions and trajectories, and these texts (in the broadest sense) arise because of differences, but complexity requires us to reflect on whether the texts generated are leading towards the appropriate, intended transitions.
2.3 Gaps in the literature

With a thematic review of the literature conducted, based on the four themes introduced in Chapter 1, a number of gaps in the literature are identified, where it is intended that contributions to knowledge useful to the design research community can be made. These gaps are outlined below.

First, while there is comprehensive discussion regarding reflection in the literature, it is nominally described as something to do with action, but without clear indication of how the process works or why it is useful. Particularly useful is the critique by Eraut (2006) and Hébert (2015) highlighting a lack of critical engagement with the subject. In our study, emphasis will be placed not on reflection directly, but through understanding difference, I intend to develop a critical perspective outlining what is being reflected upon, and in what way. Second, the review of narrative as a subject of examination within design research implicates it as something other people do, such as Celikoglu’s (2017) position of viewing narratives as qualitative data, able to help designers build better meaning-making approaches through understanding the experiences of others. There is little discussion of how narratives are generated and understood as outcomes of their own process, beyond some discussions by Tracey et al (2016) connecting it to a mode of discourse aligned to reflective thought. With regards to narrative, an opportunity exists to develop a better understanding of narrative transitions through a position adopted more in line with Bleeker (2009). Third, almost all design research, as noted in the introduction, strives to show the richness of design through the designer interactions with materials and artifacts on the scene (Baaki et al., 2016). In our study, positing narrative as a mode of discourse which is aligned to a particular mode of thought will be examined through discourse alone, to focus primarily on seeing narrative transitions primarily through the medium on which it is based — in talk. These three gaps in the literature
provide us with new territory and an opportunity to critically examine the research question outlined in Section 1.2.1.

2.4  Next Steps

Here in Chapter 2, I’ve examined through a thematic literature review, conducted systematically as well as organically, how others in the field have addressed and examined the topics and concepts of concern that I outlined in the introduction, leading to the formation of our research question which I hope to address and answer. Having mapped the literature and identified potential gaps in thinking, it requires some discussion of the methods and approaches which will be employed in order to address and answer those questions posed. Chapter 3 follows, outlining our Research Methodology, highlighting and reviewing the scope of potential methods, scope of research examination and the relationship to knowledge generation, whilst providing a practical outline of the work undertaken in the dissertation and justifying this approach against claims of epistemological validity and theoretical appropriateness.
In terms of the prevailing norms, academic respectability calls for subject matter that is intellectually tough analytical, formalizable, and teachable. In the past much, if not most, of what we knew about design and about the artificial sciences was intellectually soft, intuitive, informal and cook-booky. Why would anyone in a university stoop to teach or learn about designing machines or planning market strategies when he could concern himself with solid-state physics? The answer has been clearly: he usually wouldn’t.

(Simon, 1996)
3.1 Introduction

The literature review in Chapter 2 provided us with a set of questions driven by our motivation for undertaking this study, through an examination of what other scholars and writers who have gone before us have presented about our themes of inquiry through keyword searching. To address these questions, some structured way of addressing them is required to be undertaken, through an empirical examination of activity in the wild. Chapter 3 provides an outline of the research methodology which will be employed in this examination, leading to new knowledge and a richer understanding of our hypothesis, going forward. The chapter requires a discussion of the nature of knowledge, our theoretical position about how knowledge is generated and meaning is made, as well as a study of the appropriate methods and the selection of those that were employed in the research study, providing data necessary for analysis and interpretation.

3.1.1 Methodological Frames

With an hypothesis presented and our questions posed, how does a research project get formed that enables us to begin an examination of those questions, leading to insights, and generating new knowledge for the field? Chapter 3 defines our research methodology, and provides some context for the types of methods to be used, why these methods have been selected (over others), how these methods are aligned to a theoretical position and an epistemological position regarding our understanding of how knowledge is generated. This approach is distilled from Crotty’s *Research Cascade* (1998), illustrated below in Figure 10.
Crotty’s purpose with the cascade is to help frame various steps necessary when engaging in research intended to contribute to the production of knowledge, particularly in the social sciences. This involves the researcher being sensitive to the application of an appropriate set of methods, directed through some study of what possible methods are appropriate (methodological imperative). This, in turn is guided by the nature of the questions to the theoretical perspective held by the researcher about the production of knowledge, that is, the belief of how knowledge is actually created. The theoretical perspective is guided by the epistemological position, that is, held beliefs of the nature of knowledge itself.

But not all research is isolated to knowledge production within academia. In many instances, and particularly in design research, research may involve application and implementation in industry, leading to the development or implementation of new tools and applied methods for the field. These may, in turn, require returning to the field to observe and understand how these new tools are operating, leading to new theories, and even newer tools. Eckert & Stacey (2003) outline this in their 8 step “Spiral of Applied Research” framework, suggesting a stepwise approach to research which draws from empirical observation of practice, development of theory from empirical accounts, construction of tools to address theories, and finally validation.
to tools, theories and observations through implementation back into the field. With respect to this thesis, our emphasis remains within the empirical observations of design behaviour, with recommendations leading to novel theoretical insights, but not yet addressing tool/process development, intervention nor evaluation.

3.1.2 Chapter Outline

The overall purpose of this chapter on research methodology is to address both of these frameworks, in combination, providing a rich picture of the thesis project rationale, structure, and approach, including methods adopted in data collection and analysis. The chapter comprises 5 sections, framing various perspectives regarding knowledge, theory and application as we move through the chapter, leading to an outline of the research project structure. The remainder of the chapter is structured as follows.

Section 2 discusses the epistemological position, theoretical perspective and methodological imperative from Crotty’s research cascade (1998), which frames with the overall nature of the research project relative to our understanding of how design knowledge is generated, and explored, based on work by authors outlined in literature review, and the questions derived from that exercise.

Having outlined the nature of the research project to be undertaken, Section 3 outlines our methodological scope, based on the examination of the methods employed in previous studies of design activity and behaviour, which have made significant contributions to advancing the field in commensurate ways to this study. Whilst Crotty’s framework supports our understanding of the nature of a research project, examining the methods of previous studies highlights two predominant approaches to studies of design by design researchers, between observation and theory in academia, and the development and application of theory, leading to
tools and processes that can be implemented in industry. Which of these two positions is adopted involves understanding the complex nature of the design research and the researcher’s intentions and contributions, and providing a scope that outlines the limits of the study and the emphasis on contribution to the field.

Having outlined the nature, rationale and scope for research, Section 4 introduces the research project itself and provides an outline of the methods to be employed in collection and analysis of data. Given the various themes examined in the literature review, the emphasis is placed on mixed methods (Creswell and Plano Clark, 2007), embracing both qualitative and quantitative approaches, in order to provide a richness of insight. Methods to be employed are discussed, namely case study; protocol analysis and network theory, and; forms of narrative analysis. These are discussed in turn.

Section 5 concludes this chapter with a critical discussion of the methodology and methods presented, and some of the anticipated challenges we might expect with the research project methodology, and associated methods, outlined here.

### 3.2 Crotty's Research Cascade

The purpose of research, at least in the context of scholarship and academia, can be summarised by the definition found in the Frascati Manual:

*Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge* (OECD, 2015).

Knowledge, however, is a complex concept. By introducing Crotty’s *Research Cascade*, we invoke some of the debate around what knowledge is, and how it is understood (in relation to meaning-making) within the field of design research. Crotty outlines 4 steps, moving from the
Epistemological Stance embraced by a researcher (or their project), moving through (and helping to justify) the actual methods which are to be employed in the research project itself. In this section, I briefly discuss the steps in Crotty’s *Research Cascade* before outlining our project scope, structure and methods employed. Much of our position is already embedded within the references drawn from the co-citation analysis conducted in Chapter 2, and some of these scholars and authors will be discussed below.

### 3.2.1 Relationship to the literature

The co-citation analysis provided a number of references to scholarship which directly relates to our discussion regarding epistemological position and theoretical stance, since they are formed as part of the positions that others have adopted, returned through the thematic search of the Web of Knowledge conducted in Chapter 2. If the co-citation analysis revealed the foundational thinkers associated with our search terms, through their mutual presence in the bibliographies of others, it can also be understood that when searched records are referencing philosophical, epistemological or methodological positions, those citations will also appear in our network. Before we review those authors appearing in Table 2, it will be helpful to explain (briefly) what Crotty means when he refers to Epistemological Position and Theoretical Stance.

The epistemological position, referred to by Crotty at the apex of his *Research Cascade* in Figure 10 refers to the belief a person holds about the nature of knowledge itself. To start, consider two overarching premises regarding epistemology. The first premise involves a knowing subject, coming into the world, already possessing all the knowledge of the world, and through encounter or observation with an object, aligns this object to their conceptual framework. In this view, commonly referred to as objectivism, meaning is already embedded in the objects of the world, and only needs to be uncovered. An alternative view is that this knowing subject comes into the world as a blank slate, with no conceptual framework available
in advance, and through engagement and interacting with objects in the environment, they come to construct meaning about these objects and their encounters with them. This position is commonly referred to as constructionism, where meaning-making is situated in the knowing subject. A third perspective might be considered, where the knowing subject encounters an object in the world that is actually another knowing subject. Through this encounter, meaning-making in the knowing subject is affected or imposed by the object (the other knowing subject). This third position is normally referred to as subjectivism. Crotty outlines that many scholars and researchers conflate constructivism with subjectivism. He suggests that the confusion exists between the belief that meaning is constructed from the world that already exists (constructionism), and the belief that meaning is created and applied onto the world before us (subjectivism):

...subjectivism, comes to the fore in structuralist, post-structuralist and postmodernist forms of thought (and in addition, often appears to be what people are actually describing when they claim to be talking about constructionism). (Crotty, 1998)

Returning to Stumpf & McDonnell’s 4 design paradigms, outlined in Table 3, we can see that three of the paradigms involve individual designers working independently with things in the world. The fourth paradigm, that of design through a social frame (the one to which this thesis has aligned itself) involves multiple participants engage in argumentation, attempting to build consensus. Arguably, our epistemological stance, involving two or more knowing subjects involved in project-based approaches to design, may involve perspectives from constructionism, but also from subjectivism. Our epistemological position, however, is certainly not based in objectivism. This position is supported by the presence of certain scholars and academics within our co-citation matrix, generated in Chapter 2.

Reviewing the literature review co-citation matrix, presented earlier in Table 2, highlights two key thinkers, whose presence supports our epistemological positions described earlier, but
provide somewhat differing theoretical perspectives which may need to be discussed. The appearance of John Dewey (1963), one of the leading proponents of pragmatist thought, should come as no surprise, having already been introduced in our discussion regarding reflection, and influencing the future works of Kurt Lewin, David Kolb, and importantly, Donald Schön. The theoretical perspective held by the pragmatists was that knowledge and eventually meaning, were generated in the knowing subject engaged in actions with their environment. Dewey outlined this process more thoroughly through his theory of inquiry, where his articulations regarding reflective thought were derived. A detailed explanation of the theory is beyond the scope of the thesis, but the curious reader is referred to a very helpful paper provided by Schön (1992a).

More importantly, however, is the appearance of Paolo Freire’s work *The Pedagogy of the Oppressed* (1970). Arguably, Freire’s work has a lot in common with Dewey; both situated in education, both attempting to build an educational process that leads to personal emancipation through inquiry-led knowledge generated through interactions in the world. But a significant difference emerges in that Freire’s epistemological position is that of critical inquiry, more closely aligned to subjectivism than the constructionist leanings of the pragmatists. Though Freire might support much of the pragmatists’ views, his theoretical position was influenced by critical theory, since he was aware that the environment and the context in which inquiry was supported was itself constructed, and these environments were not neutral. Institutions such as governments and universities operate through consensus, like the paradigm of social design which predicates this thesis. Yet, those people who participate in reaching consensus are often able to select others, often like themselves, to achieve a consensus that best serves their interests, whilst oppressing others. Freire’s theory was formed in the poorest neighbourhoods of Brazil in the 1960s, where formal education was often limited, and approaches to learning often standardised and directed, without consideration of the learners.
For Freire, inquiry on the part of the learner was not enough. Real emancipation would require a critical stance examining the structures and institutions upon which learning itself were operating, that is, the student needed to also reflect on who was imposing the approaches to knowledge on them. This is an important position that takes into account that knowledge practices and processes are often structured by someone who holds a particular view, stance or belief, and these views should also be subjected to practices of inquiry. Ideas from Freire’s work continue today, notably in post-colonial perspectives calling for a decolonisation of the curriculum (Charles, 2019), often perceived as biased towards favouring a particular ethnicity’s view of the world being propagated through the institutions of higher learning.

To summarise, the approach to the thesis so far provides some insight into the nature of knowledge and how it is produced. It should be clear that knowledge practices will not be found out in the world, rather, they remain situated in particular contexts and are produced by the knowing subject. However, caution should be applied to seeing the world as neutral, where the situations and contexts in which learning takes place are themselves structured by others, who may hold differing views and positions, which raise the possibility that inquiry can be directed, and knowledge and meaning imposed. This places us somewhere between the epistemologies of constructionism and subjectivism, where our theoretical perspective about the world is driven through a combination of pragmatism and critical inquiry. This position, so far, seems to accord with our supposition that our project is situated in Stumpf & McDonnell’s paradigm of design as in the realm of the social (Stumpf and McDonnell, 2002).

For our purposes, I will argue that this analysis is sufficient. Crotty himself acknowledges that crossover and blending of these positions is highly likely, outlining that they are not clearly defined, bounded concepts. For our purposes, to return to our conclusion in Chapter 2 discussing difference as the variable under examination, we might suggest that both these
positions deal with difference in some form, either constructed from what already exists, or created and applied to the world around us.

And given this position, how do we go about conducting an empirical examination of design projects, their associated texts and narrative, where difference is being reflected upon in some way? The methodological imperative I intend to apply requires some discussion. Referring back to our co-citation matrix (see Table 2 in Chapter 2), a number of names appear which provide us with some clues. First, grounded theory is an important methodological approach developed by Barney Glaser (Glaser, 1967) and Anselm Strauss (and later with Juliet Corbin) (Corbin and Strauss, 1988). Grounded theory was a necessary development, where Glaser and Strauss were examining the experience of death. A key conundrum in such work is how to understand the experience if the participant is unable to relay those experiences to researchers, after death? Clearly, no theory could be established, which could then be tested after the study had concluded, so a new approach was required that involved developing theory from data (from the ground up). This situated approach to research involved situated observations of a variety of participants and extensive semi-structured interviews. Coding interviews allowed for the emergence of themes and patterns, resulting in theories being constructed from the presence of recurring themes, outlining how meaning is made by individuals in a particular context. Grounded Theory has spawned a whole variety of qualitative research approaches, and many of the leading authors on the various approaches of grounded theory are found throughout our co-citation matrix (Lincoln and Guba, 1985, Miles, 1994, Patton, 2002, Braun and Clarke, 2006, Charmaz, 2006). Much of the approach to qualitative analysis and grounded theory involves a situated approach to research in communities of practice (Lave and Wenger, 1991, Wenger, 1998), employing a variety of methods involving observation, reporting and descriptions of the circumstance. Though a list of methods available for any grounded approach is non-exhaustive, some selection of methods, discussed later in this Chapter, will be
made easier if the scope of the project can be clarified through our methodological framing. This is most usefully done through a cursory examination of other studies employing similar methodological approaches within design practice and design research, examining the types of methods that have been used in previous studies examining similar research questions.

3.3 The Research Project: Overview and methods

Analysing prior research studies of empirical design behaviour, constructing evaluations of those studies, leading to the development of theory provides a scope and frame for the project, but remains generic and abstract. Details about the who, where and when of the research project will naturally flow from articulating the why, leading to the how. From Chapters 1 & 2, the why associated with this thesis involves examining relationships within the design project between project narratives, reflective activity and difference. Specifically, our research project and related questions look to postgraduate product design students managing their individual design projects, where narratives are one type of textual output (amongst many), generated through reflecting on their actions and experiences in addressing difference. Given the complex nature of projects, involving multiple stakeholders, multiple sites of action and extended temporal frames, some way of understanding how design students manage difference across time will be required, implicating that one single method is unlikely to be available for our purposes.

3.3.1 Mixed Methods

Rather than selecting any particular method to examine a research question, Creswell (2007) argues that mixed methods are more useful in providing a well-rounded approach to understanding research questions. In particular, he suggests that mixed methods is an approach which embraces both qualitative and quantitative perspectives within a single study, suggesting
that either approach alone informs half of the question under examination, particularly in social science research. Mixed methods approaches adopt a position whereby the research collects and analyses data, both qualitative (words) and quantitative (numbers) in nature; combines and integrates the data and results; structures their research to include both method types in a logical way, and; frames their rationale for engaging mixed methods theoretically and philosophically.

Eckert & Stacey (2003) outlined earlier the multiple interpretations by research practitioners examining design practice, and those different disciplinary and theoretical positions may require different methods, in combination, to understand the whole picture. For example, understanding meaning in design conversations have been explored through approaches involving semantic analysis, often predicated on the frequency and diversity of noun usage in early phases of design conceptualisation (Mabogunje and Leifer, 1997, Dong, 2005, Stacey et al., 2009, Georgiev and Casakin, 2019). Such approaches would be prime examples of mixed methods approaches, examining both words (qualitative) and frequency (quantitative) approaches in tandem, in line with Creswell’s definition of a mixed methods paradigm.

The thesis dissertation intends to employ a mixed methods approach. The first method which I outline in this section is the case study, which will introduced a series of product design projects undertaken by a cohort of postgraduate students across one academic year. The case studies will provide insight into the role that texts and narratives play within the product design projects of the postgraduate students. For our purposes, a discussion of the particulars of different student projects is necessary, since each individual project is situated in a variety of sites, involving multiple stakeholders and impacted by the passage of time. The projects require some description and framing, to understand how students’ are reflecting on evolving narratives, managing difference, articulated as driving design. Case studies provide a macro-level perspective, and to understand reflecting on the construction of texts, including prototypes
and narratives involving difference, some micro-level interactions will be required, to see how the circumstances within the heterogeneous project space is managed.

Through the case studies, I’m able to outline the structure of the product design studio experience when engaging in a project-based approach to designing. One of the key project activities involves regular design meetings between tutors and student, known as tutorials, where project updates and prototyping developments are discussed, which enable healthy project progression in the lead up to students submission of their final project outcomes, including the design book outlining the rationale and process of prototype developments, as well as the final designed product prototypes.

Prototypes are often outlined as being a type of boundary object (Star and Griesemer, 1989, Star et al., 1989), but are also framed as intermediary devices (Vinck and Jeantet, 1995, Boujut and Blanco, 2003, Eckert and Boujut, 2003, Vinck and Blanco, 2003), facilitating collaborative activity. These tutorial sessions, involving discursive activities about prototypes in the making are key intermediary steps within the projects themselves, and I apply the same theoretical consideration to these tutorials as the objects normally under discussion, considering these sessions as intermediary events in the project timeline. These conversations highlight prototypes as well as narratives in development, and the transcripts provide us with protocols about the transitions which may give indications about difference. Seeing the transcripts of tutorial interactions as design meeting protocols allows for the application of our 2nd method in linkography (Goldschmidt, 2014), a form of network graphing analysis measuring design activity. This process is contrasted to other graphing tools (namely Gephi) and the associated network metrics constructed through these respective tools in measuring design activity associated with students reflecting on narrative construction and difference.
Graphing and network analysis provide one measure regarding linkages between things, but there are alternative approaches available to the examination of narratives in development and transitioning in the project, structured around difference. Forms of narrative analysis (Riessman, 2008) give us insights into narratives and themes, however they don’t give us insights into narrative structures, grammars nor transitions. A particular approach to understanding narrative, predicate on rewrite logic (Martí-Oliet and Meseguer, 1996, Meseguer, 2012), involving rewrite rules and operators, comes in the form of Quantitative Narrative Analysis (Franzosi, 2004, Franzosi, 2010). Franzosi’s approach, like linkography, is a bespoke method developed to understand the examination of collective narratives held by many people, and witnessing how and why these change. Franzosi’s work is based on understanding the rise and fall of Italian Fascism in the 1920s from the multitude of newspaper articles and texts available which are predicated on narrative syntax and grammars (Todorov and Weinstein, 1969, Labov, 1972, Halliday and Matthiessen, 2014). Franzosi’s approach is presented as being complementary to linkography, but emphasizes in vivo coding based on tracking the constituent elements in the narrative event frame — subject, action, objects, space and time. This approach is normally applied to large datasets and provides statistical insights into narratives, allowing for cross examination on events impacting features on the narratives, through a qualitative framing. This method of examining the tutorial transcripts, using the narrative event frame is made readily possible using natural language processing tools (such as NLTK or Stanford’s NLP libraries) in order to be able to separate parts of speech, and parse sentences into constituent event components, and tracking changes between speakers in the exchange to understand how difference is being managed. Parts of speech tagging provides flexibility to code events into event types, based on the types of verbs used by relevant speakers in the transcripts.
These four methods (case studies, protocol analysis, network analysis, quantitative narrative analysis) provide the framework on which our data will be examined and analysed. These methods (and respective tools) are discussed in the following three sections of this chapter.

### 3.3.2 Descriptions of Empirical Engagement: Project Case Studies

Our thematic search and the results in the co-citation matrix returned to citations associated with the first method to be employed in examining our hypothesis - the case study. A case study approach enables a broad examination of design development as it unfolds in a product design studio, providing us with an empirical grounding for our study (Stake, 1995, Yin, 2009, Tight, 2017). Rich case descriptions also provide us with more detail about postgraduate product design student projects, beyond the anecdotal accounts outlined in the introduction in Chapter 1.

Yin (2009) outlines that case studies based on multiple-case design can have advantages over the single case approach, particularly that evidence generated through a multiple case approach is perceived as more compelling, and offers greater robustness. The conventional approach to case study normally involves examination of special cases under rare or unusual circumstances which provide deep insights into outlier events and exceptional situations which help to inform patterns and construct evidence beyond the status quo. A criticism of single case study is an apparent inability to move from specific instances to generalised circumstances, considering evidence beyond the study itself.

Case studies are common in disciplines where empirical descriptions are used in place of experimental studies. The case study provides a bounded space for examination and accounting of extreme circumstances, highly novel events, or situations that are considered exemplary and unique in order to develop insights regarding the case in question (Tight, 2017).
Multiple-case design in case study research provides an opportunity to ascertain, through multiple bounded cases, an in-depth understanding of events and drivers across cases sharing some aspects of structures across them (Chmiliar, 2012).

Yin describes three particular approaches to multiple case studies. Exploratory case studies are those which are engaged in advance of a formulated research question, and are often seen as pilot studies in preparation for larger work to be undertaken. Explanatory case studies are those which align cases discussed with established theoretical positions in order to ascertain a degree of fitness between practice to theory. Descriptive case studies outline how cases under question are supportive and validating established practices to confirming theoretical positions.

An exploratory approach is the basis of the explanatory study of "reflecting-in-action" through a web of moves posited by Schön in his account of Petra and Quist in the architecture studio (Schön, 1983, Schön and Wiggins, 1992, Schön, 1992b). The single case study has had enormous impact, leading to subsequent scholars and researchers to examine design activity from a number of alternative experimental as well as additional interpretive ways. As discussed earlier, the case study is somewhat unclear on a number of things, namely the context of the interaction (designing architecture or teaching architecture) and the role that Quist plays in that context. The case description, outlined at a micro-level through a particular interaction, only glances over other key details which would help strengthen the case. The objects of design are only discussed in passing, as a design brief, and a site plan for the execution of plans and drawings. The evaluation of the project is not available, but the jury of peers who will assess all students work is only briefly mentioned. The context is an architectural design studio, and though other students are mentioned, the nature of the interaction (a critique or a tutorial? Public or private?) is not clarified, nor is the role, location or influence of other students who may be witnessing these same constructions.
Significant case studies of design activity and practice involve detail descriptions derived primarily from ethnographic studies, and remain highly descriptive were outlined in the STS approach discussed in Chapter 2 (Bucciarelli, 1988, Minneman, 1991, Cuff, 1991, Yaneva, 2009a). Approaches such as these adopt a fieldwork approach described by Kuhn as "going native" (1962), or by Latour & Woolgar as "visiting a foreign tribe" (1979). In such cases, the researcher is initially an outsider, who joins the community of practice where the action unfolds, to observe, describe and construct an account of their research agenda, in situ. The results are richly descriptive, and interpretative in scope, and provide empirical insights generated from observations of witnessed design behaviour, often useful in developing theoretically driven, scholarly accounts of designers’ behaviours and practices (Eckert et al., 2003).

Case study approaches employed within design literature sometimes involve participatory design investigations, situated within a research by design paradigm where novel design methods are constructed, and employed, and participant feedback solicited to understand impact (Strickfaden, 2006, Westerlund, 2009, Bowen, 2009, Bowen et al., 2016). In these circumstances, the researcher is often embedded in the circumstances as a facilitator of the action, not necessarily observing and operating as a witness to design behaviour; rather developing tools and procedures that may facilitate these design activities when incorporated into an industrial or professional environment (Eckert et al., 2003).

Another approach within case study analysis, as outlined by Yin and Tight is to study extreme or novel circumstances to ascertain how these outliers operate and might inform mainstream approaches by drawing new general insights from particularly exceptional examples. Bryan Lawson advocates this perspective, through interviews with and examining works of pre-eminent engineers, architects and designers for insights about how mainstream practice might benefit from learning through experiences of experts (Lawson, 2004, Lawson, 2006).
This research project will adopt a multiple case study approach, where a cohort of 12 postgraduate product design students are followed over the course of one academic year, as they engage in their projects. Chapter 4 will discuss these cases in detail to provide insights into difference at a macro level, bringing into focus the various sites in which students are engaged with various members of staff, but also to introduce the coursework submissions which help form the basis of the students’ projects themselves, employing a light touch approach to content analysis (Krippendorff, 2013).

### 3.3.3 Analysing Talk: Network Analysis

If case studies provide us a macro perspective on the student design project, we are only able to generate insights which are very general, without insights into details about the mechanisms associated with difference, reflection and narrative transitions within the project. To do this, a micro level interaction will be required. The case study approach outlined that design tutorials, an intermediary events within the project, provide a useful starting point to consider how students and their tutor discuss the project, as it unfolds over time, in the studio. These discussions, when captured and transcribed, might be thought of as design protocols, and subjected to appropriate protocol analysis, examining how language and text operate as "think-aloud" schemata possibly revealing insights into designers’ cognition (Ericsson and Simon, 1984).

Philosophers and social scientists have long been interested in the nature of language, whether written or spoken. Philosophers like Austin (1970), Grice (1957), Quine (1960) and Searle (1979), amongst others, were interested in language beyond information exchange or structural forms, a perspective seen in cognitive approaches to language, in studies such as those from Shannon & Weaver (1963) or Chomsky (1957). Rather, social scientists viewed language use as an act itself, as something which can shape social interactions as well as allowing for
information transmission, sometimes by breaking the rules which in everyday conversation, are often not adhered to.

Gee puts it usefully as such:

Discourse analysis is the study of language-in-use. Better put, it is the study of language at use in the world, not just to say things, but to do things. People use language to communicate, co-operate, help others and build things like marriages, reputations and institutions. They also use it to lie, advantage themselves, harm people, and destroy things like marriages, reputations and institutions. (Gee, 2011)

Discourse analysis presents a variety of approaches to studying language. Some approach discourse at a macro level, examining distributed texts that propagate various ideologies and shape cultures and societies; other approaches to discourse analysis examine micro level perspectives involving interactions as a situated and contextual phenomenon. Discourse analysis has received significant attention in design research over the past decade, and these approaches to designers’ talk-in-action is outlined in Chapter 2 in our discussions of narratives.

Despite this interest in talk-in-action, Chai & Xiao report that protocol analysis has been the most commonly reported methodological position within design research, as reported within Design Studies (2012). Protocol analysis was introduced by Ericsson and Simon (1984), who posited that discursive transactions such as verbal reports of problem-solving activity may provide helpful insights into how people solve problems, by asking them to talk through their steps, whilst doing them, in the activity. Retrospective protocol analysis asked participants to solve a puzzle, and after the fact recall their steps undertaken. More useful was concurrent protocol analysis, where participants were asked to report on their steps towards the solution as they were engaging them. Though this presents a significant cognitive load for participants, it was understood to provide real-time insights into cognitive function in experimental problem-solving circumstances.
A particular method associated with protocol analysis of design activity is linkography (Goldschmidt, 2014). This method is proposed as our initial approach to examining of our tutorial transcripts, when understood as protocols.

Linkography, the practice of constructing a linkograph, has strength in its approach to visualising the unfolding design moves as part of an overall design process, uncovering structures of design cognition, in action. Linkography is a particular approach to graph theory employing link-node analysis, resulting in atypical arc-diagrams (McGuffin, 2012). The linkages constructed are relationships between utterances made by a designer during a structured design activity and engaged in “talk-aloud” practices associated with protocol analysis, revealing “design moves” being made across the design exercise.

Linkographs are understood as a useful approach to examining "design moves" through protocols in design research (van der Lugt, 2000, Kan and Gero, 2005, Kan and Gero, 2008, Gero et al., 2011, Pourmohamadi and Gero, 2011). Linkography was originally proposed and developed by Gabriela Goldschmidt, as a method to visualise design interactions, to see “design moves”, and uncover various aspects of design in action, including creative thinking (Goldschmidt and Tatsa, 2005, El-Khouly and Penn, 2013); conversation topic shifts (Botta and Woodbury, 2012), and; designer focus through entropy measure (Kan and Gero, 2005).

Engaged in the same dataset as Cross & Dorst, based on the Delft Protocols (Cross and Cross, 1995), Goldschmidt was concurrently examining whether design teams were more productive than designers working alone (Goldschmidt, 1995). Goldschmidt’s prior research interests were less about social processes and more focussed on cognitive ones, having already published influentially on the role of visualising, sketching and drawing as part of rational reasoning apparatus of designers, in the cognitive domain (Goldschmidt, 1994). In order to do this, Goldschmidt extended the use of protocol analysis and developed a particular link-
node structure to protocol transcripts she called linkography (Goldschmidt, 2014), which allowed for the discovery of “design moves” as they emerged in design discourse (think-aloud protocols) while designers were simultaneously busy with a prescribed design exercise.

Goldschmidt describes the core business of linkography as such:

\begin{quote}
Links are based on the contents of moves. Deciding whether two moves are linked is done by using common sense under the condition of good acquaintance with the discipline and with the design episode in question. (Goldschmidt, 2014)
\end{quote}

Linkographs are constructed by linking utterances or statements across a corpus to each other, based on a coder’s intimate understanding of the interaction, and a familiarity with the discipline in question, following Goldschmidt’s suggestion that a common sense approach to the linkographic exercise be adopted. Beyond that, there are no formal instructions nor guidance for how to construct a linkograph dataset in order to generate an appropriate network diagramme which highlights utterances as moves within a design episode.

The bulk of studies which use linkography follow an individual designer, working on an established brief, constructing primarily concepts and ideation at the front-end of design work. The significant majority of these briefs deal with architects, working over drawings. The work of Botta (2012) is one notable exception, in examining a group meeting involved in the development of a design curriculum. Another exception, and noteworthy for our studies, is the work of Goldschmidt, Hochman and Dafni (2010) examining student-tutor interactions in architecture studio “crits”.

Much of the examination of design work involving multiple actors is predicated on no notable differences between the success of individual designers over design teams (Goldschmidt, 1995). The constitution of a “design team”, however can be challenged on the basis of the types of design interactions being investigated, for example, when designer and clients are
discussing a provisional drawing or model of anticipated design goals and objectives (Luck, 2007, Luck, 2009). Recently, examinations of design team dynamics, based in organisational studies and perspectives of psychology, have ascertained that conflict-resolution skills are as important as problem-solving aspects of successful teams at work in design in alleviating uncertainty about common goals amongst team members (Paletz et al., 2017).

Linkography is a specific approach to networks which employ node-link analysis. Broadly speaking, node-link analysis does not receive significant attention within the design research community. The use of node-link analysis requires only a few variables in order to start constructing a network: something is connected, along some dimension, to something else (Tufte, 2001, Wilson, 2010). Social media platforms, like Facebook, employ the approach by connecting two people if they consider themselves "friends". Example networks can include the examining characters in a play and connecting them to each other depending on whether or not they appear on the stage at the same time (Bastian et al., 2009). The co-citation analyses conducted in chapter 2, and the resulting graphs presented in Figure 3 and Figure 5 are examples of social network analysis in practice (White and McCain, 1998).

Kolleck (2013) employs social network analysis in the examination of innovation, in particular how innovation is diffused through social networks leading to change, highlighting that despite the use of graph theory in the understanding of social networks and how they highlight relational connections between finite sets of actors, there has been limited application through empirical study in the field of innovation and future studies of the method. Chai et al (2012) and Beck & Chiapello (2017) both employ network analysis in the examination of bibliographic references employed in design research, which provided some rationale for conducting our own co-citation analysis in Chapter 2. Kim & Kim (2015) employed social network analysis in the construction of maps to ascertain cognitive styles amongst design practitioners, discussing a wide variety of representations used to understand design thinking.
prior their study, including excerpts from protocol studies, discourse analysis and linkography, but this appears to be the only article within the design research community examining design moves, cognition and activity from a social network perspective.

Other disciplines in the digital humanities situated in phenomenological inquiry also employ link-node analysis, through more extensive approaches such as social network analysis (SNA), epistemic network analysis (ENA) (Shaffer et al., 2009), or dynamic network analysis (DNA)(Carley, 1991). SNA is the most generalised of these node-link practices, adopted in the humanities to study networks of relations in the social world, often employing large datasets associated with social media platforms like Facebook and Twitter.

These differing approaches to node-link analysis share a common approach to linkography in their execution, but do so through more clearly defined data, and often being implemented of more readily available sets of tools, discussed later in this chapter. What makes linkography perhaps unique, is the requirement of a coding scheme which is associated with identifying what types of design moves each link represents, normally situated within discrete utterances. Coding schemes are generated in relation to particular research questions and agendas. One notable framework with an associated coding scheme is the Function-Behaviour-Structure (FBS) ontology (Gero, 1990, Gero and McNeill, 1998, Gero et al., 2011). The ontology and framework scheme outlined by Gero and company does not come without criticisms and detractors, particularly with regards to slippery definitions and shifting meanings of the key terms, such as function (Vermaas and Dorst, 2007, Galle, 2009). Perry & Krippendorff (2013) confirm this concern with their report on lack of evidence in inter-coder reliability during scheme coding exercises involving data based in design activities. The exercise of linking utterances in linkography supersedes coding, but is nonetheless predicated on making judgements about which “node” (a word, sentence, phrase, etc) is “linked” to others in a
protocol due to a perceived relationship through possession of shared attributes or properties, commonly referred to as “link-node” graphing.

3.3.4 Analysing Narratives

Linkography provides us with a transactional view of talk-in-action, but as will be discussed at the end of chapter 5, it doesn’t provide insight into narratives, narrative transitions driven by reflecting on difference. A third method is introduced into our mixed-methods approach to this dissertation project, which is predicated on examining narratives and associated transitions predicated on highlighting the changes taking place across utterances, when understood as event clauses in the narrative frame, based on an underlying structure known as a story grammar. The approach we will employ is adapted from a methodological approach to examining changing narratives, known as Quantitative Narrative Analysis, or QNA.

The co-citation analysis from chapter 2 uncovers two scholarly works which describe approaches to narrative analysis (Bakhtin and Holquist, 1981, Clandinin and Connelly, 2000). Narrative analysis is the examination of textual work and understands particular structures relevant to stories people tell each other in their descriptions of the world. Narrative analysis seeks themes and perspectives in texts which circulate through societies and cultures and shape those cultural systems in their propagation. A particular feature of narrative analysis differentiates it from the analysis of storytelling. Though stories do not necessarily need to be true (fairy tales and myths are prime examples), narratives are predicated on depictions of situated events which are understood to have occurred, but are interpreted by various communities who come to make sense and meaning from these events in the construction of relations and identities amongst community members engaging in the construction and dissemination of narratives.
Within design research, narrative has been examined by a number of researchers, already mentioned in Section 2.3.4. In particular, Tracey & Hutchison (2016) relative narrative to the act of reflection itself, seeing the practice as the construction of personal narratives which help to recount and frame previous experiences. Narrative, and narrative analysis, help to situate how we make sense of the world through the discursive practices we engage with others.

Narratives are understood to have a basic structure of subjects engaged in action, sometimes with or towards various objects/recipient. In short, someone did something (to someone or something) (Labov, 1972, Halliday and Matthiessen, 2014, Riessman, 2008). Narrative analysis is primarily phenomenological in approach, but recent work has begun to adopt quantitative perspectives to narratives, drawing from the basic structure of [subject:action:object] and applying computational processes to allow mining across large volumes of text in order to ascertain patterns of narratives over time (Franzosi, 2010). Quantitative Narrative Analysis shares many features with graphs and networks in its approach to structures, and these are discussed in more detail in following section.

Narrative analysis often examines particular narrative types and particular structures associated with these types to understand how they are constructed, and the various roles they play within social communities. Much of this involves a micro-level view of narratives, employing a [subject:action:object] orientation. This perspective does not necessarily outline how narratives work at macro-levels, circulating through and across communities of practices, and how they evolve over time. Franzosi (2010) provide an approach to quantitative narrative analysis (QNA) which sees the basic narrative structure as a material in itself, as a semantic "triple" which is shaped, circulated and in turn itself shapes, local narratives and communities employing them.
Franzosi’s work is quantitative in nature, while examining phenomena which are normally perceived as qualitative and phenomenological. When asked what value or purpose exists in turning words (or narratives) into numbers, he outlines that it is a methodological perspective based on volume and quantity. Managing narrative structures through the examination of a particular folktale in a particular culture requires different tools of analysis than examining 180,000 newspaper articles over a period of a decade reporting on the rise of fascism in post-war Italy, his area of expertise. To this end, Franzosi implicates that there are narratives which circulate through networks and in turn are both shaping and shaped by those networks. To understand the patterns involved with large datasets, qualitative approaches are not suitable since there is too much material to manage, in this way, and emergent patterns obscured. He states it as such:

*I make no superiority of a quantitative approach to narrative texts. I quantify simply because I have far too much information to deal with qualitatively* (Franzosi, 2010).

QNA, he argues, highlights patterns in global narrative sets; while maintaining a view that the actual narrative content shapes locally due to its phenomenological nature and appeal. This perspective has implications for Franzosi’s approach through QNA in that a quantitative analysis examining patterns in circulation does not emphasize themes to content, nor translations of words into intermediary codes (Franzosi, 2010). The position is similar to those adopted in social network analysis, where a particular thematic is outlined as a relational construct across the network, highlighting how things are linked together, not necessarily dealing with qualities or themes that connect them. It contrasts to the positions of more qualitative approaches such as narrative analysis, protocol analysis, linkography and epistemic networks which aim to address qualitative perspectives of knowledge and information, managing movements through typologies of knowledge, rather than witnessing the flows alone.
These perspectives are critical to the ways in which text as data is managed and analysed, and informs the types of computational tools associated with the exercise. Some of the tools available, and in particular those used in the remainder of the dissertation, are outlined below.

### 3.4 Discussion: Methodological choices challenges and critical perspectives

The previous section outlined a variety of methods, corresponding to competing methodological approaches, associated with the examination of design projects and associated protocols at intermediary points within project case work. The choice of methods, and methodological perspectives were presented as being contingent upon theoretical and epistemological positions, as outlined in Crotty’s research cascade, discussed at the start of this chapter and presented in Figure 10. Having presented and justified our mixed-methods approach for the study, this final section of Chapter 3, I outline some anticipated challenges and controversies which require explanation in advance of engaging the mixed methods approach outlined in the earlier section.

#### 3.4.1 Situated Research

One significant challenge in observing design practices is to first identify where design is happening, in order to understand how design knowledge is constructed, in context. Another challenge in examining talk and discourse in action is understanding the context in which the talk is taking place. Situated research methods operate on the premise that knowledge is constructed in the situation, in the moment and the environment in which it is generated (the situation) is a strong contributing factor. With this in mind a number of significant challenges were associated with observing design students engaged in their project.
First, the nature of design covers a variety of technical and process operations. Studios are intended for drawing, workshops are intended for making, critique spaces are intended for discussion and presentation, and depending on the institutional context, these spaces may be co-located, or they may not exist at all. The students who form the case studies in this dissertation operate in a Design School that employs three distinct spaces for these critical activities, with one (the workshop) being in a distinct and separate building elsewhere on campus. A fourth location which is often employed by students as a site of work is their personal residence, often working from home until late hours in the evening. The nature of the situatedness associated with the case studies, observations and data collection are predicated on attempting to find some structural stability in order to find some patterns across cases. In this instance, decisions were made to follow the teaching timetables established in the syllabus where it was (mostly) understood that student and tutor interactions would be taking place. However, given the nature of design practice and student engagement, it is difficult to make direct comparisons across cases, since no two students, despite being co-located in the same studio, are engaged in a similar project structure. It is acknowledge that the educational design studio operates differently from professional design studios; one being a place of learning and teaching, the other being a place of work, both being very distinct cultures and situations in which designers are operating, potentially causing challenges for data collection and robustness of materials from which to draw good analytical insights.

### 3.4.2 Embedded Research

One of the ambitions of design research is to find ways to get as close to the action as possible. Empirical studies provide an opportunity to observe the world directly. In qualitative studies involving other human subjects and communities, it often requires acknowledging the roles
that one holds as a researcher situated in the scene, potentially impacting the data collection activities in unforeseen and unintended ways.

Studies involving ethnographic immersion often involve the researcher "going native" (see (Kuhn, 1962)). The challenge of the researcher then is to suspend their role and identity as a researcher and situate themselves as part of the community action in order to develop first hand empirical accounts of the action as it unfolds. However, this is perhaps easier said than done. Empirically speaking, objectivity is often associated with researcher distance, allowing for unbiased observations (if that is at all possible) allowing for empirical reports to be grounded in the community, and not influenced by the researcher within the community. Lewis describes the notion of being embedded as a researcher while conducting case study examinations (Lewis and Russell, 2011), particularly when engaged in social science disciplines examining reflexive practice. Beaulieu (2010) discusses co-presence rather than co-location, highlighting that ethnographic researchers are often assuming that direct-observation and engagement requires an active spatial proximity to the site of data collection (co-location), and challenges this in suggesting that that co-presence as a concept opens up other avenues for understanding data collection with active involvement, but through more passive, non-intrusive means.

If an embedded approach in this research project is useful to some degree since the implication is that it allows examination as close as possible to the action of design, without resorting to challenges associated with artificial experimental conditions. However, embeddedness can only occur to a certain degree in this instance, if the same person is adopting both roles as tutor and the researcher. Given that these are actual, credit-bearing projects situated in educational contexts, a particular power dynamic in the student-teacher relationship in unavoidable. This relationship may cloud some aspects of the design process unfolding in the studio, as the student may perceive themselves and their skills being judged and assessed, rather than observed.
This challenge is not an isolated problem for researchers in social sciences, particularly those engaged in studies of the work place. Being present in the studio tutorials allows for intimate access without disruption, but the researcher often aims for an objectivity and places themselves in situations where they are an outsider, hoping to remain objective, but often mere presence is enough to disrupt the flow of everyday action. An emergent approach in studies of the workplace involves the insider-researcher (Saidin, 2017, Fleming, 2018), which allows for the benefit of a researcher with intimate knowledge of the context of the space and scene under examination, whilst being able to retain their role in the community without disrupting others. However, there are challenges to adopting this position, namely the real risk of researcher bias and directing observations to subjective concerns due to increased familiarity with particular aspects of the environment in which they are engaged (Costley et al., 2010).

The approach adopted in the dissertation to get access to the studio interactions without interfering with the smooth flow of action involves combining perspectives of co-presence and insider-researcher, resulting in a hybrid approach to embeddedness. Agreements were reached with all students involved that allowed for audio capture of tutorials without the imposition of further cues about research being conducted — laptops, phones, and audio recorders were already being used by students in tutorials to capture fast and fluid conversations as they unfold in the tutorial, without interference or interruption from additional research equipment present, possibly negatively affecting research activities capturing the events unfolding. Other materials collected, framing the case studies, were works completed for assessment by students within the course, and not evaluated for research purposes, in order to avoid conflating research and education practices further. However, it is acknowledged that the institutional setting and the student-teacher contract within the educational context may have implications for the type of data collected and appropriately available for analysis. A conscious decision was made by myself as the insider-researcher to not transcribe, review or analyse recordings collected until
after the conclusion of the student studies, essentially creating a portfolio of collected work void of research intentions or ambitions, in order to establish some objective distance between myself and the data being collected and interpreted.

The tutorials, as intermediary events in the project, which are captured using minimally intrusive equipment, already expected to be present in the tutorial. The tutorials selected for analysis in the research project were those where the tutor acts as a "critical friend", or coach (Adams et al., 2016b), with an implication being that discussions in tutorials of this type are structured as formative feedback as opposed to summative assessment. In this view, an informal contract between the student and the tutor exists where there is an understanding that these tutorials are aimed to help, or assist, the student in troubleshooting their projects and helping to remove barriers which may be understood to negatively impact on successful project completion.

3.4.3 To code, or not?

Qualitative analyses of interactions are predicated on the deployment of a coding scheme in order to identify themes and uncover patterns in the analysis of data. In applications adopting a grounded theory approach, coding schemes emerge from the data through iterative applications and refining of schemes, leading to theory construction. Protocol Analysis, linkography and ENA construct codes apriori the actual coding process, to understand typologies and classes of knowledge occurring and unfolding in the sequences of utterances, where each statement in the dataset is allocated a code to identify it as a particular type of move taking place. Particular critiques of coding for content, specifically aimed at linkography, suggest researcher interpretation of codes, and application against interpretations of statements, results in challenges associated with inter-coder reliability, and study replication across projects (Perry and Krippendorff, 2013).
Computational processes like NLP, or QNA (Franzosi, 2010) do not apply qualitative codes to transcribed materials, rather the processes embrace in vivo codes based on rules within established grammars which generated the text in the first place. Franzosi compares his story grammar coding to conventional coding schemes associated with content analysis:

*In content analysis, coders play a greater role in the coding process than in a story grammar approach...*

*Coding, in content analysis, assigns text to aggregated codes, typically theoretically defined. Data coding and data aggregation go hand in hand, the coder performing both tasks. In a story grammar approach to coding, coding consists of applying parts of text to the natural and familiar categories of a story: who was involved, what they did, when, and where. Coders are not involved in theoretical decisions...* (Franzosi, 2010)

Identifying patterns in text and language using computationally driven approaches like latent sentiment analysis or natural language processing (NLP) takes this approach even further in confining processing to comparative parts of speech, and rules of grammar, being drawn from existing texts, but no analysis of content applied. 7 Aggregated coding of data into discrete themes is not a methodological consideration.

Given these very distinct processes to text and talk as data, the question about coding, or not, seems pertinent; but we should return to the methodological and theoretical perspectives outlined in Chapter 2 pertaining to this particular thesis. The imperative outlined intends to examine moving between structures and across boundaries which contain those structures, with an eye to suggesting that reflection, if instigated by an ambiguity, doubt or uncertainty, requires some difference to start the process. The nature of the difference, whether it be degree, type or flavour, in the examination of the hypothesis is of less interest than the examination of how difference is first identified, managed, and impacts on future design oriented decisions. In this

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7 Aspects of NLP are used in a method called sentiment analysis where particular n-grams are identified as having positive or negative connotations, and messages within text classified as having particular sentiment. The process maintains an objective view to what has historically been regarded as a domain of qualitative analysts.
way, aggregated coding schemes would be of use to understand different move types, not necessarily how difference makes moves. A decision to forego any aggregated coding was made in lieu of understanding a grammatical approach associated with difference, rather than types or degrees. In Chapter 9, a discussion outlining future work extends the grammars of difference to consider types and degree of difference and how this current work might be extended.

In an attempt to be more explicative and transparent with our approach in examining moves, and difference as it drives design, a structured approach connecting links based on word occurrence within the transcripts was proposed. The ambition is to uncover patterns from word frequency in discourse, in order to nurture a potential coding scheme for future applications and interrogation of remaining cases.

### 3.5 Final thoughts

Chapters 1 through 3 outlined our initial dissertation phase, providing the motivation and rationale for undertaking this project; a review of the relevant literature which frame this project, and; establish a foundation for our examination, highlighting the methods that will be undertaken in our inquiry to evaluate the project narratives being reflected upon, through the generation of different narrative frames and texts through product design activities. The next phase of this dissertation moves from rationalisation for the study, towards descriptions, analysis and insight generated from the study itself.

#### 3.5.1 Data and methods of collection

This section provides an overview of the methods used, the manner in which data was collected and the nature of the data analysed in the subsequent Chapters 4 through 8.
Over the course of one academic year, 13 postgraduate design students were involved with this research project through interactions, data collection, and observations taking place in the studio. The students formed an international cohort, with a variety of different prior-study backgrounds, ranging from industrial design, product engineering and business studies. One student withdrew from the programme in the first semester, one student did not progress to dissertation, and three students were enrolled in an MFA variant of the programme, a two year programme which shared a common curriculum for the first two semesters with their MA counterparts. The cohort of students who enrolled started the academic year are case profiled in Table 5 below.

<table>
<thead>
<tr>
<th>Student</th>
<th>Nationality</th>
<th>Gender</th>
<th>YoB</th>
<th>Background</th>
<th>Degree</th>
<th>Notes</th>
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<td>1986</td>
<td>Business Studies</td>
<td>MA</td>
<td></td>
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<td>1968</td>
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<td>MA</td>
<td></td>
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<tr>
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<td>Male</td>
<td>1989</td>
<td>Product Design</td>
<td>MA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Engineering</td>
<td></td>
<td></td>
</tr>
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<td>BL</td>
<td>Irish</td>
<td>Male</td>
<td>1985</td>
<td>Furniture Designer/Maker</td>
<td>MA</td>
<td></td>
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<td>Male</td>
<td>1982</td>
<td>Mechanical Engineering</td>
<td>MA</td>
<td></td>
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<tr>
<td>GY</td>
<td>Korean</td>
<td>Female</td>
<td>1986</td>
<td>Industrial Design</td>
<td>MA</td>
<td>Failed to progress to degree</td>
</tr>
<tr>
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<td>Female</td>
<td>1983</td>
<td>Art &amp; Design</td>
<td>MA</td>
<td>withdrew from programme</td>
</tr>
<tr>
<td>AACC</td>
<td>China</td>
<td>Female</td>
<td>1987</td>
<td>Jewellery Design</td>
<td>MA</td>
<td></td>
</tr>
<tr>
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<td>Industrial Design</td>
<td>MA</td>
<td></td>
</tr>
<tr>
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<td>Greek</td>
<td>Female</td>
<td>1986</td>
<td>Product Design</td>
<td>MA</td>
<td></td>
</tr>
<tr>
<td>DS</td>
<td>Greek</td>
<td>Male</td>
<td>1986</td>
<td>Mechanical Engineering</td>
<td>MFA</td>
<td></td>
</tr>
<tr>
<td>JM</td>
<td>Spanish</td>
<td>Male</td>
<td>1985</td>
<td>Mechanical Engineering</td>
<td>MFA</td>
<td></td>
</tr>
<tr>
<td>SK</td>
<td>Greek</td>
<td>Male</td>
<td>1986</td>
<td>Product Design</td>
<td>MFA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Engineering</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Student profiles from the cohort under examination

MFA students were omitted from this study due to differing length of their study. Two students who started the MA failed to complete their studies. In total, 8 individual MA students were observed while engaging a self-directed, independent project of their choosing, through their studio courses, supported by a variety of staff and tutors. Overall points of contact for the year, and times of data collected, are outlined in academic timeline illustration outlined below.
in Figure 11. The timeline is demarcated per week, with points above the line representing interactions where data was collected for this study; points below the line represent general points of contact between students and various tutors on the programme.

![Figure 11: An overview of the MA academic timeline outlining contact points between tutors and students during the study. Points above the axis outline those where data was collected, marks in red outline periods of non-contact.](image)

Data collected across the project came in various formats. At the commencement of the project (Semester 1, week 1), a written proposal, containing three project outlines, was collected from each student. At week 3 in Semester 1, students presented their preferred project in a visual poster presentation to staff and fellow students, which was also retained. These materials were analysed against the work submitted at the end of Semester 3 in each student’s final design project book, which captured their understanding of personal design decision-making and project trajectory, from initial goal setting to final outcome delivery. In Semester 2, during studio development and the production of prototypes, reflective interactions were captured in 1:1 tutorial sessions with students, as well as group critiques involving multiple staff and all students. When possible, photographs of objects were taken, or provided by students in digital format, following the tutorials.

Three cases were selected for presentation and discussion in this thesis, selected due to the robustness of information available from the student throughout the academic year, clarity of recordings and transcripts during design episodes, and the students’ successful completion on the MA programme. These three cases represent a selection of students with a range of personal experiences, various undergraduate degree training, language skills, gender, ambitions and intentions, and perceptions of product design is defined, as a discipline. The
three cases presented are each described in various stages, and support documentation provided to highlight particular points of interest across the respective academic careers.

In Chapter 4, a light-touch approach to content analysis is employed to examine the project development of the three student cases, at a macro level across the course of a year, and makes explicit use of examining written and visual accounts of initial project descriptions and visuals, with those submitted at the end of the programme through the design book. Chapters 5 through 7 address the respective project transitions, at a micro-level, examining how decisions were made, and executed, through audio recordings captured during student-tutor tutorials, and photographs of physical artifacts and materials which were under discussion at the time. In the end, 7 sessions of student-tutor interactions were employed, with intervals of two weeks between sessions, providing 02:29:48 hours’ worth of recordings. These sessions were transcribed professionally and returned as text documents, allowing for further processing and examination. Metrics generated with the interactions from each session through linkography and social network analysis, including length of tutorial, number of turns taken by each participant, number of topics discussed, and the relative importance statements within each tutorial are presented in Chapter 5. Particular excerpts from tutorial topics are presented in Chapters 6 and 7, highlighting particular approaches to turn-taking and narrative development, through story-grammar framing using Quantitative Narrative Analysis.

Following here, Chapters 4 through 8 provide detailed descriptions and analysis generated from the three cases of students engaged in individual projects situated in a postgraduate product design studio, through the data collected across a full academic year of interactions with students, in situ.
The approach of design on the world is projective. By this I mean that, for designers and researchers, the world has to be perfected, it is a project and not just an object that must be described, whose causes must be explained or whose meaning must be understood.

(Findeli, 2006), as cited by (Vial, 2013)
4.1  Introduction

The introductory chapter of this study presented a set of concerns regarding the education of design practitioners. Historically, reflective activity through inquiry-led epistemologies has shaped much understanding of design practice, and much of that work, it was discussed, has emphasised micro-cognitive approaches to problem-solving. In practice, student designers are often being asked to reflect on projects and their personal efficacy in organising processes leading to novel outcomes, through design. Our literature review highlighted that projects are often retrospectively presented through stories and narratives, presenting an apparently linear process moving rationally from problem analysis, through to synthetic development, leading to the presentation of a potential solution. In contrast, however, design research scholarship has placed significant emphasis on forms of localised decision making (design moves; reframing) as opposed to the importance of the coherence of consecutive moves in an overall project context. The end of the literature review posed questions about the focus and emphasis of reflective activity when design practice is examined at the project level, and the associated retrospective accounts designers present to their audience highlighting their approach to personal design projects. Our site of study at this time is particular to the discipline of product design.

4.1.1  Overview

This chapter of our research study focuses on interactions with three postgraduate product design students engaged in their individual practical projects over the course of one academic session. The methodological approach adopted was that of the case study approach (Yin, 2009, Tight, 2017), with multiple cases under examination, situated in a common academic
programme structure, time and location, in order to introduce the reader to a selection of projects under examination. This was outlined in Chapter 3.

This chapter provides a multiple case study analysis, constructed from three student projects which were selected for detailed empirical descriptions in the examination of our research question derived from the 4 thematics and presented at the end of the literature review in Chapter 2. Chapter 4 is structured in the following manner.

Section 2 outlines the overall academic programme as the site of inquiry, providing an overview of the structure of the academic programme. The section outlines both an organisational and pedagogical perspective, since both have an impact on the nature of the design projects undertaken, and the manner in which product design projects are understood and engaged. The various locations where the programme operates (the studio, the workshop, the critique space, and beyond) are presented and the relevance of these various places where product design is taking place is highlighted, with emphasis on the relation to the programme’s overall philosophical perspective.

Section 3 introduces three student projects which form the basis for the multiple case study, (Yin, 2009, Tight, 2017) providing an account of each overall student project, constructed primarily from three sets of documents. First, project proposal outlines submitted by each student provide an early rationale for their MA project ambitions; second, initial design project ideas are supported by a visual poster presented to the studio jury; and third, their final project workbook submitted at the end of the academic year as a retrospective account of their work and decision making process, including their final prototypical developments, as a response to their earlier initial problem interests. Reflective statements provided by each student at the end of their project, as a component of the design book, were also examined.
Section 4 concludes the chapter with a discussion of the case studies, and outlines the importance of the project, and the relationship between reflection and narrative. Project-based learning was discussed in the literature review as a contrast to problem-solving learning, and here the emphasis on the narrative as a project output outlines two major narratives in play: the current narrative, as framed with people engaged in interaction with existing objects, and the future narrative, where the interactions are involved with the new prototype, as representation of a variation on the object yet to be. The notion of a narrative transition, of moving from the existing narrative to the preferred one, becomes the basis of the student design project, where the difference between these narratives are the focus of design. Implications, challenges and next steps in Chapter 5 are outlined.

4.2 The Programme

The case studies which are to be outlined in this section all took place over a single academic year, within a post-graduate programme of study in product design at a UK institution of Higher Education (HE), which consists of three disciplinary “colleges”; Humanities and Social Sciences (CHSS); Science and Engineering (CS&E) and Medicine and Veterinary Medicine (CMVM). The product design programme, one of 12 programmes situated within the collective subject area entitled Design, is based within the University’s College of Arts, Humanities and Social Sciences, as opposed to the College of Science and Engineering.

4.2.1 Different perspectives on Product Design

The point here is that despite overlap in approaches and practices in the design domains, there are distinct epistemologies at work across this organisational structure. Product design, as a discipline, is sometimes (mis)-understood as synonymous with industrial design engineering, with some emphasis to the “softer” side of engineering practices. Things such as shape, form,
colour, materials and finish are relevant areas of inquiry in both industrial and product design fields; so too are function, usability, and human factors. When comparing topics engaged between these disciplines, we see significant overlap between them — however, when comparing theoretical perspectives about objects, artefacts, systems and people, we see more distance in approaches, methods and theories when thinking about people in disciplines of science in contrast to social sciences.

The emphasis in this description about the programme of study is not to validate one position over another, but rather to outline possible underlying assumptions about the nature of product design as understood by this programme, its staff and the institution in which it resides, based on the boundaries identified in the organisational structure. As described in the introduction, the programme is aligned to the Arts and Humanities, and employs a human-centred perspective (Brown, 2009), situating itself more closely to the disciplines of social science, as opposed to the hard sciences found in STEM-oriented subjects.

4.2.2 Programme structure

The teaching programme for all new entrants to postgraduate product design studies commences in September. Prior their arrival, prospective students were asked to generate three project ideas or descriptions for their potential personal project direction in a pre-established challenge area or thematic strand, outlined by the programme director and the programme staff.

The project outlines submitted by prospective students, prior the start of the formal teaching year, are circulated amongst staff involved with studio teaching. Informal evaluations were made based on the perceived strength of the outlines submitted, the ability for students to manage the proposed projects, and the topicality of projects attempting to address some form
of change, facilitated through new product development. The proposals are primarily textual, though visuals which support arguments are requested.

The challenges outlined by students in the thematic propositions are primarily issue-based, resonating more with wicked problems (Rittel and Webber, 1973) than with incremental improvements associated with problem-based product design development. The textual nature and supporting visuals provided suggest each student’s understanding of the existing situation, in narrative format, while framing the challenge situation to be changed, altered, modified, or simply made better. Neither the solutions to the challenge, nor the pathways to delivering them, are clearly evident at this point.

According to the degree prospectus at the time which these case studies were engaged, the postgraduate product programme was described as involving research, development and production of prototypes which communicate lines of investigation regarding the quality of people’s lives, and how product design might contribute to making things better.

Outlined at the close of Chapter 3, two degree pathways were possible for students within the product programme; a one year pathway which results in the degree title of Master of Arts (MA); or a two year pathway resulting in the Master of Fine Art (MFA). The MA and the MFA are common in the first year of teaching. After these two semesters, MA students conclude their dissertation project over the course of consequent summer. The MFA students are afforded a summer holiday, and return the following academic year for 3rd taught semester, and conclude their study in the spring semester with their respective dissertation project conclusion.

Teaching on the programme was split between practical work in the studio, consisting of seminars and tutorials, as well as lecture-based classes in history, theory and context, shared across all programmes in the Design School, fostering a critical examination of both personal
practices, and the field of design more broadly. Academic tutors who delivered these theory-based courses were often from allied disciplines in the humanities, as opposed to being studio practitioners themselves.

At the time the study was undertaken, the degree programme structure and the courses available to students followed the format outlined below in Table 6.

<table>
<thead>
<tr>
<th>Programme Timeframe</th>
<th>Courses Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1</td>
<td>Design Research (40 Credits)</td>
</tr>
<tr>
<td>- Shared</td>
<td>Research Methods (20 Credits)</td>
</tr>
<tr>
<td>Semester 2</td>
<td>Design Studio (50 Credits)</td>
</tr>
<tr>
<td>- Shared</td>
<td>Studio Theories and Context (10 Credits)</td>
</tr>
<tr>
<td>Summer</td>
<td>Design Exposition (50 Credits)</td>
</tr>
<tr>
<td>- MA Dissertation</td>
<td>Exposition Theories and Context (10 Credits)</td>
</tr>
<tr>
<td>Semester 3</td>
<td>Design Studio 2 (40 Credits)</td>
</tr>
<tr>
<td>- MFA only</td>
<td>Studio Documentation &amp; Distribution (20 Credits)</td>
</tr>
<tr>
<td>Semester 4</td>
<td>Design Exposition (50 Credits)</td>
</tr>
<tr>
<td>- MFA Dissertation</td>
<td>Exposition Theories and Context (10 Credits)</td>
</tr>
</tbody>
</table>

Table 6: Degree Programme Structure

Those courses on offer which are comprised of 40 credits or more are studio-led. The pedagogical emphasis in the studio is facilitating reflective practices through student-led projects, nominally in a discursive format about work students have already undertaken, or are planning to undertake. The mode of interaction between academic teaching staff and students is primarily through individual and group tutorials, where tutor, student and external discipline experts reflect upon development and project progress. Technical and practical work is supported by technicians based in a variety of specialist workshops. The emphasis in the studio is to develop a contribution to students’ future professional portfolios of work, encouraging each student to identify, investigate and develop the most appropriate and personally relevant object-oriented solutions to the challenging problems people and communities face. The structure of this particular programme, as a practice-led approach to product design and
development in the studio environment, shares much in common with competitor programmes across the UK HE sector.

4.2.3 The courses

Having submitted an outline of three potential projects to the academic staff in advance of their studies, students arrive on programme and begin studies in earnest through a set of defined course structures. Studio based courses were the most significant component of each student’s academic career. The MA programme, with three semesters, has 140 out of a total 180 credits in the studio, whereas the MFA, with 4 teaching blocks, has 180 from 240 Credits as studio components. Each of the three studio courses had distinct learning outcomes, and each provided a particular frame into product design practice through which students were engaged by staff in addressing their individual project approach. This section describes the studio based courses undertaken by the student and provides some useful context outlining how courses relate to programme structure, but also personal project directions.

The first studio course, titled Design Research, fostered approaches to allow each student to engage in appropriate design research activity, ascertaining product design opportunities from a review of relevant secondary data sources (precedent object analysis; literature reviews; policy reports; etc) as well as primary data sources (interviews & focus groups; action research; material experimentation, etc). Within the studio teaching, emphasis was placed on analysis of current situations and circumstances, developing a design brief, and a series of possible artifact propositions by the end of the semester, which outlined future development work in Semester 2.

The second studio course component, titled Design Studio, brought the artifact proposals, design briefs and plans presented at the end of the previous semester forward. The course
emphasized exploration, design development and synthesis of ideas and experiments, leading to prototyping through generative and iterative means, incorporating a variety of technical media and processes outlined by the student as being relevant to progressing the design project in the appropriate direction. Work in progress is strongly supported by workshop technicians who are able to outline to students appropriate materials and technical processes in the development of models, prototypes, and experiments, which are presented at the end of this 2nd semester course for summative assessment.

The 3rd and final course component of the academic year takes place during the summer. Design Exposition provides an opportunity for students to conclude their project, and present their project work in a common form of dissemination, the year-end exhibition. The course takes into account that new audiences will see the student project work for the first time, and the content, including the prototype, supporting text, graphic, and other presentation materials, necessary to effectively communicate the project, its purpose and process to a wider audience.

As each student progresses through the courses while on programme, the prototypical artefacts are anticipated to progressively increase in their degree of fidelity. This progression indicates the students’ abilities to iteratively synthesise their analytical and empirical findings in design-led research and development, whilst also progressing their project from research driven concepts, through to exhibition-ready proof of principle artifacts. Assessment of the work in each studio course, however, is done through the submission of a project portfolio, at the end of each semester, when the courses naturally conclude. The portfolio submission is centred on the emergent project and the outputs associated with it, but also allows for the inclusion of work which the student believes best addresses their ability to evidence the learning outcomes attached to each course. It is the learning outcomes which are assessed in accordance with the assessment regulations outlined by the institution at the start of the academic year. The use of learning outcomes provides some degree of objectivity and transparency in the assessment
process, and avoid the use of personal preference by assessment teams (Biggs and Collis, 1982).

The portfolio is quite flexible, but normally contains a collection of work which highlights the student’s activities over the semester, consisting of drawings, models, prototypes and summaries of findings from literature and precedent object reviews. Students are also asked to prepare a short summary of the project work outlined in their portfolio at the conclusion of the semester. This summary is a visually supported verbal summary, presented to the jury of assessors. The assessment panel consists mainly of programme staff, and on some occasions external experts from the field.

This approach to assessment, and the specific wording of the learning outcomes as listed in Table 7, resonates with many design process models. More explicitly, there is a strong overlap between expected learning in students’ design projects and Jones’ simplification if the design process to the triadic action of analysis; synthesis; evaluation (Jones, 1970).
Across all three teaching blocks, as projects and artifacts develop, students are asked to keep a “design book” which is submitted as part of their final component as part of their dissertation exhibition in the Design Exposition course. Each student compiles their research work, their studio work and their insights regarding design exposition and communication into a compiled text which provides an overview of the design project undertaken. The text is often written retrospectively, and provides insights into the student’s perspective of an optimised design trajectory over the course of the project. Though it is expected to be an honest account of process, rather than a description of project, much of the uncertainty experienced “in the moment” of the design process over the year has been forgotten, edited, or romanticised within the text (Nelson et al., 2013).

4.2.4 The studio
The studio acts as a hub for various activities including group teaching, lecturing, and tutoring; small scale making; writing and drawing; presentation and critiques; and conversation, discussion and socialising. The relationship between the studio and the education of designers is an area of significant research in design pedagogical research (Schön, 1985, Moultrie et al., 2007, Farias and Wilkie, 2016)

Studio courses, which facilitate engagement by the student in their individual project, take place in the common programme studio location, where students on programme are allocated a dedicated desk space from which they work throughout their postgraduate study. The programme studio performs multiple functions. It acts as a workplace for students to engage their coursework and self-directed projects as required by their individual trajectories. It also provides a teaching space for interactions between students, academic tutors and external experts involved in providing advice to students over the course of their study. The studio also acts as an exhibition and dissemination space, with multimedia projection and audio/visual capabilities in order for students to project presentations, film/video, and other works in progress, while also allowing external speakers and presenters to show works in progress and provide lecture facilities.

The studio starts the academic year empty, but quickly fills up with drawings, maquettes, small scale models, precedent images, texts and post-it notes. The studio is home to a great deal of activities and is the centre of the postgraduate student’s academic activity, though a few activities associated with the design process take place out with the confines of the studio proper. Activities such as fabrication must be done in the appropriate workshops. The critique space, a multi-use quiet space is available, and can facilitate presentations, pinups, group seminars, and notably 1:1 interactions between student and tutor, when more direct feedback about personal progress may be required.
4.2.5 Workshops

There are a variety of central workshops within the University which are available for student use while on the programme of study. These workshops host a variety of larger equipment and machinery, suited to specialist fabrication activities. These activities fall into two particular mode of working; craft-oriented practices and digital-oriented practices.

Specialist craft-oriented workshops are widely available and provide support across a range of practices. Two main workshops support woodwork and metalwork, and house specialist equipment including stationery equipment (bandsaws, table saws, drill press, welders, etc) as well as associated bench tools, both hand tools and powered (routers, planes, screwdrivers, drills, grinders, etc). There are an additional number of smaller, specialist workshops that are not directly connected to the product design programme, but still are accessible by the students as secondary users. These workshops include specialist metal work practices associated with jewellery, such as casting, enamelling, and soldering; glass blowing and casting facilities, including an associated plaster workshop; textiles and fashion workshops including access to facilities for dye chemistry, screen printing, knitting machines and sewing facilities, amongst others. A print workshop, supporting traditional methods of screen printing, plate printing, lithography and other craft-oriented production methods for graphic document creation is available, but the nature of this work finds product students making little to no use of these specialist facilities.

Digital oriented practices of production are often employed during the creation of prototypes, models and complex components involving computer aided design (CAD) hardware and equipment. Some of this equipment, such as laser cutters, multi-axis routing machine, a plasma cutter, 3d scanners, and high end ALM printing equipment are found in a specialist digital fabrication workshop. Some smaller 3d printers are available in other analogue workshops,
since computer files can be uploaded locally through the use of memory cards, allowing easy transportability of digital files across physical spaces. Computer labs, which are open access and also serve as teaching facilities for developing skills in specialised software, are located throughout the campus. Students are also able to make use of personal computers and laptops with a campus wide cloud platform facilitating document printing and file exchange across locations, devices and platforms.

All workshop equipment, whether physical, analogue or digital, is maintained by dedicated technical staff, with whom students have direct connections and working access in order to ensure safe operation and technical learning associated with equipment operation. Some equipment requires specialised inductions and supervision (i.e. table saws); other equipment is open access to all following brief operational inductions (i.e. shared computers and printers).

4.2.6 The critique space

The critique space, as part of the overall studio space associated with this programme is isolated from the studio proper.

The practice of critique and its relationship to creative practice and skills development is well studied in research into design education. (Uluoğlu, 2000, Murphy et al., 2012, Verhoeven, 2012, Scagnetti, 2017). Within our study, the critique space was used in conjunction with two forms of critique occurring across the course of the academic semester:

- the “group crit”, where one student presents their work to the rest of the cohort, including academic staff, for interrogation
- the tutorial, where the interrogation of work in progress is normally discursive and remains localised between a tutor and an individual student.

The critique space is pictured below was used in both formal and informal instances, shared also across multiple programmes of study in the School. The blank walls were not decorated,
and left blank, in order to facilitate an assortment of pinups and projections associated with group presentations. Furniture is spartan, and moveable, allowing for conversion between a site involving desk-based conversation, or gallery-based presentations. The critique space, where the majority of observations in this study occurred, is presented in Figure 12.

Figure 12: The critique space

The critique space is the location where tutorials conducted during the 2nd semester course Design Studio were conducted and recorded, as primary data for future developments in this study. The conversations were captured between the tutor and individual students discussing and presenting pertinent design materials including material samples, prototypical constructions, drawings, websites, parts and components waiting to be assembled or integrated. All these additional materials, supporting the conversational tutorials, are understood as intermediary objects (Vinck and Jeantet, 1995) in an emerging process where next steps are negotiated, ratified and determined through design specific boundary objects (Star et al., 1989).
While each course required students to evidence three Learning Outcomes in their final coursework assessments, evidenced through a portfolio of submitted material and a final presentation to studio staff, student projects generally span courses, moving between project phases of research and analysis, prototyping and development, and finally onto dissemination and exhibition.

For MA students, the final dissertation takes place over the summer. Design Exposition is the course component where the objects, images and texts generated throughout the programme of study are synthesised into an exhibition format and presented to a public audience, where the developed stand or exhibition is intended to communicate the design challenge through text and image, with a proposed object solution presented in exhibition ready models and prototypes, supported (where applicable) with video. An overall “project book” outlining the design, development and project trajectory over three semesters is compiled and presented in association with the exhibition, providing a synopsis of the student’s insights and approaches to design which have led to the final models presented.

Those students who studied as part of the two year MFA pathway are free during the summer, following their shared first year of study with the MA cohort. The MFA students return in the fall of the following year to engage in a second studio course (Design Studio 2) where emphasis is placed on user engagement, product testing, and iterative development. This enables the MFA students to determine an added degree of success in their project proposal approaches, understanding the impact that prototypical responses generate through the engagement with other people. MFA students conclude their studies in the 2nd semester of their second year, through the course Design Exposition, identical in content and delivery to their MA counterparts, and resulting in a degree show exhibition at the end of the academic session.
4.3 Three Cases - an introduction to student projects

In this following section we introduce three of the 8 MA student projects followed and observed in this study, to highlight the narratives which have been developed across the entire academic year, through various components of assessment, submitted at different times across the year.

4.3.1 Grasshopper Skateboards

Grasshopper Skateboards is a project undertaken by BL, a native of Ireland where he did his undergraduate degree in wood furniture design, which placed an emphasis on technical construction and material understanding as a foundation of all project work. In particular, through early conversations with BL, it is uncovered that one area of wood engineering where he has strong interest is bending and lamination, particularly in the area of bent wood lamination using radio frequency curing.

BL’s initial project proposal, submitted to the programme staff for review, outlined his initial intentions, outlined in the following introductory paragraph:

My personal area of interest is the design and development of a range of modern, contemporary, multifunctional furniture with integrated technology, to facility (sic) the homes of the future.

Based on initial conversations at the start of the academic year, he outlined that interest in the product design programme as one which would help develop deeper technical skills regarding the development and production of wood furniture. His proposal outlines an interest in trends towards small living spaces and multi-functional furniture, understanding not only shape and function, but that “new and existing materials and manufacturing processes must be carefully considered…” The proposal outlines a desire to explore multimedia integration, citing examples where audio components, lighting components and electronic controllers are
embedded into the functional components of the artefact. He hopes to work “…directly with any technology, engineering and multimedia departments that the college has to offer …” in his proposed design project. He further suggests a critical perspective regarding multi-function furniture will assist in his finding a market niche, but also points out that he hopes to “…meet the needs of the selected end user”, suggesting that function and utility remain central to his investigations for future furniture designs.

Discussions with BL outlined that his interest in this technique could be accommodated to some degree within the structure of the programme, particularly with colleagues outside the programme directly and in other areas of the University, particularly in Architecture, as well as Structural Engineering. It was pointed out to BL in these early discussions that there would be some constraints to the project, since the specific equipment he hoped to experiment with was not available in the workshops supported within the programme. Another consideration discussed was clarifying what he hoped to achieve in pursuing this particular direction; that is, the project purpose, since it was not clear what type of question or challenge he was setting for himself to explore in a designerly way (Cross, 2001).

BL outlined that he hoped to explore particular technologies associated with wood manufacture and experiment with various structural forms leading to innovative furniture designs, some of his initial ideas being very ambitious and requiring significant technical insight and support which were difficult to provide directly in the existing programme structure.

A suggestion was made to simplify the approach and find a field or topic which supported the interrogation of the technical processes of wood engineering, and continued to address many of the claims his proposal hoped to address: function, performance, materials and technical processes, and sustainability. It was suggested that the programme valued critical interrogation or a questioning stance of a design related topics in student projects, rather than direct focus on
technical competence or manufacturing techniques. It was highlighted that the programme was situated within the humanities, rather than engineering, as has been outlined in the description of the programme outlined earlier in this chapter.

Following initial discussions with staff, BL an initial poster presentation outlining his product design project proposition in visual format. The poster is shown below in Figure 13.

Figure 13: Project poster from Rapid Prosthetics Week 3
The overall design project pathway, entitled Grasshopper Skateboards, is outlined in BL’s final “design book” which outlines a retrospective account of BL’s project and process over the course of the academic year, including research, studio development work and his final exhibition presentation. The “design book”, as outlined earlier in section 4.1.3, is a required component for assessment, and is compiled throughout the year outlining a project process pathway from concept, through development to final presentation in exhibition format.

BL outlines his final project in the design book in the opening paragraphs:

The tree, among nature’s finest creations plays a critical role in the ecosystem and as such has been an important model and metaphor in my thinking. For almost 50 years the Canadian maple tree has been used as the prominent material in the production of skateboard decks and is currently the number 1 contributor of mass deforestation.

He outlines his overall design intentions in the next paragraph:

The use of an alternative material expresses my intention to evolve away from the use of wood fibres in the construction of skateboards and seek a more effective solution. Design goals are quite specific: To make a skateboard that is both attractive and affordable, meets regulations, outperforms its rival Maple decks, lasts longer than current market expectations and is made from sustainable materials which are renewable, environmentally safe and biodegradable.

Skateboard decks are constructed using a laminated wood construction from veneer sheets of Canadian hard maple. BL outlines in his final design book that the process of fabrication of these decks involved techniques of manufacture that he was interested to learn more about, but also that the material composition (maple) of the decks was contributing to significant environmental degradation due the extensive use of this particular wood. According to BL’s research, decks had a limited lifespan, were composed of additional materials (deck tape on the outer skin, bonding resins in the core lamination) which made recycling of the wood difficult or impossible. BL outlined that he would like to design and fabricate a skateboard deck that
was ecologically sound, 100% recyclable and remained competitive with other standard maple skateboard decks, which had a monopoly in the current marketplace.

Initial discussions over the semester led BL to understand that a core requirement of his project would be to demonstrate that any deck that he developed would have to compete with existing decks across a variety of categories; strength; weight; flexibility; economics; and recyclability. BL also outlined an ambition to be able to ensure that all materials sourced for his design project would also meet environmental and ethical standards, contributing to what he hoped would be a 100% eco-friendly board. Quick market surveys conducted by BL at local skateboard shops and with local skateboarders led him to believe that there would was strong interest from this sub-culture about addressing this important, ecological and technically challenging issue.

Images in Figure 14 outline the final design developments of the skateboard deck and the appropriate material configurations and construction details determined through the course of BL’s project.
4.3.2 Rapid Prosthetics

Rapid Prosthetics is a project undertaken by RC, a Scottish male student who arrived on programme with an undergraduate degree in product design engineering. His initial project proposals outline his keen interest in “environmental design” with a personal interest of focus on “new and future applications of eco-friendly materials.”

He outlines that his choice of this particular programme is to be allow him to “…develop the manual skills I believe I lack …” and outlines that an application of appropriate environmentally friendly materials in new contexts are imperative, that “…the design industry MUST be made more eco-friendly.” The final paragraph is his project proposal outlines his project vision aimed at “…a consumer product, domestic lighting, or a piece of furniture
utilising either new eco-friendly materials or existing materials of this nature which haven’t been used in this manner.”

In early conversations with the academic team, RC expressed an interest in biomimicry, and how phenomena and principles of nature could be applied and exploited through design.

These discussions are reflected in the poster presentation during week 3, where RC is presenting precedent images of Velcro, and bottlenose high speed trains, associating the narratives of engineering inspiration derived from phenomena in nature. These are seen in Figure 15 below.
These conversations highlighted that RC understood “eco-design” to mean designing artificial systems which drew on strengths and perspectives from those found in natural ones, which he clarifies in his poster as being biomimicry. Two significant points arose from these earlier conversations and presentations. First, eco-design, as RC defined it, did not necessarily equate to sustainability; and second, the types of projects he was outlining had significant technical challenges regarding development and educational support in this domain would be limited.
In order to achieve a realisable product design outcome at the end of the MA trajectory in less than 12 months, RC may have to re-consider his project scope if a realisable prototype or model were to be developed.

Following the advice to rethink his project scope and direction, RC presented a few photographs related to technical prosthetics. Some of the precedent analysis focussed on robotic hands which could mimic human gestures such as grasping, clasping and holding. Other devices, such as the carbon fibre blade used by para-Olympians in track and field, made use of principles of materials physics, in replicating walking and running. In both these devices, RC found an alternative direction which seemed realisable, and to appropriate scale.

RC spoke to a number of people living with prosthetic limbs in the proceeding weeks, and made contact with the experts at the NHS SMART centre, which fabricated, repaired and distributed prostheses in the region. Much of this information is discussed in his design project book entitled Rapid Prosthetics, a retrospective account submitted at the end of the academic year supporting his design led research and development:

*My Masters studio work this year has been to design a body powered transradial prosthesis to improve on the current Hosmer Dorrance Model 5X Hook that the NHS still frequently provides. It is obvious that many of the materials and techniques are old fashioned or out dated, as well as the Model 5X pre-dating World War 1 itself (its patent granted in October of 1912).*

RC had uncovered curious insights into prosthetics research and development. While there is strong interest and development in robotics and the ability to fully replicate human function (particularly in the hand), the technology was neither robust nor reliable, and prohibitively expensive for many people. Two further approaches to prosthetic hands in the market were identified by RC: the aesthetic approach, where hands are shaped in carbon fibre and covered in silicon to simulate the appearance of the human hand; or the mechanical approach, where
hands are created from forged steel, and through crude mechanical functions were able to replicate some rudimentary elements of hand functionality (grasping, holding, etc).

As RC outlines in his design book, current approaches to prosthetics available to the general population were constrained by principles of affordability and economics, and this prevented good integration of both aesthetics and mechanical function. RC believed that this was primarily due to methods of manufacture:

...my work adapted and is now a project where I pre-design a generic, multiple use prosthesis, produced in stainless steel, as well as releasing the 3D CAD model from customisation for specific or special tasks that the patient would like to undertake, to be 3D printed by the practitioner.

RC outlined that current advances in methods of production (namely additive manufacturing) might be able to address the gap between mechanical function, aesthetic and manufacture, and this was met with enthusiasm from colleagues at the NHS. RC was introduced to a gentleman named Chris, a munitions expert with the UK military who despite having suffered the loss of his hand in the line of duty, continued to perform his work as a bomb disposal expert. Chris was an interesting user case study for RC. Chris, an engineer himself, had developed a series of bespoke prostheses for himself, which enabled him to continue with particular activities, one example being weightlifting. The academic team suggested to RC that working with Chris was a unique opportunity. It was felt that combining RC’s skills in digital modelling and ALM manufacturing with Chris’ insights from highly personalised prototypes could provide a strong and useful project appropriate to a product design Masters dissertation. A selection of work by RC, including intermediary printed artefacts for trialling with Chris, his specialist end-user, are included below in Figure 16.
4.3.3 Comiconnectors

Comiconnectors is the name given to the project by CT, a young female student from the United States who held an undergraduate degree in business, rather than product design. Though entry requirements outline a portfolio is required which competencies related to designing products, through interview with the programme director, CT outlined her strong interests in entrepreneurship and ambitions to commercialise her product proposals. During this stage of admissions, it was outlined that CT’s strong entrepreneurial skills might be able to compensate for her lack of formal design training.

CT’s initial project proposal outlines her interests and ambitions in addressing cognitive and emotional development in pre-school children, through developing “…emergent products that
utilise Waldorf, Reggio-Emilia, Montessori, and Piaget principles to create a fully enriching experience for the child at home.” Her design vision is to “…create curiosity-inducing educational toys, games and literature to encourage children to freely explore, experiment, innovate and seek answers.” The issue which CT is addressing, uncovered in conversations, is the perceived lack of stimulation and creativity found in current pre-school educational structures and curricula, found in the United States.

Her view is that parents, nannies, and other:

...long-term, non-professional caregivers meet the children’s social and emotional needs by providing a sense of continuity, which pre-schools and day-cares commonly lack.

The poster CT presented to staff and classmates outlining her project ambitions can be found below, in Figure 17.
The design book submitted by CT in concluding her Comiconnectors project provides a summary of her project, her approaches and her personal reflections on the experience.

The overarching project ambitions set out at the project start are re-iterated by CT in the introduction of her design book:

Figure 17: Project poster from Comiconnectors Week 3
My project aims to address the child’s emotional development in the domineering two-parent working culture. I explore the role of products in aiding the bonding of parent and child while they are physically apart.

CT also outlines the project has six goals and objectives, to focus on easing the experience of separation anxiety for both parent and child; foster opportunities for parent-child interaction; to educate parents and increase awareness towards children’s emotional needs; reduce parental guilt associated with long periods of separation; explore remote bonding over distance; and create a transitional object which fosters growing independence in children as they begin to navigate the world without their parents.

The project book outlines the key design factors which CT engaged in the development of her line of toys addressing the objectives outlined above, namely function, shape, and materiality. A selection of images of development work from CT’s form and material studies are seen in Figure 18.
4.3.4  Case summary

Each of the cases presented were analysed from three pieces of student work across their academic study. These were used in order to provide insights into the overall student project, from initial concept presentation through to final documented texts, which serve as retrospective analyses of personal work. These key points of engagement within the course provide an opportunity to examine the narrative transition across the student project through retrospective, reflective accounts by the students themselves about their projects, through their design book submissions.

A summary of initial proposal directions synthesized from the project outline and visual poster presentation, and the final design resolution from each case study, is outlined in Table 8 below.

<table>
<thead>
<tr>
<th>Student Case</th>
<th>Student</th>
<th>Initial design intention</th>
<th>Final design outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasshopper</td>
<td>BL</td>
<td>Bent laminated furniture for domestic interiors</td>
<td>Sustainable skateboard constructed from laminated bamboo and eco-friendly resin</td>
</tr>
<tr>
<td>Skateboards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapid Prosthetics</td>
<td>RC</td>
<td>Biomimetic approaches to sustainable materials innovation, inspired by nature</td>
<td>Prosthetic hand with customisable functions developed through additive manufacture technologies</td>
</tr>
<tr>
<td>Comiconnectors</td>
<td>CT</td>
<td>Early childhood development through parent-child collaboration through education and play</td>
<td>Interactive characters - &quot;comiconnectors&quot; - which facilitate early childhood emotional development in working families by maintaining parent-child bonds via distance</td>
</tr>
</tbody>
</table>

Table 8: Summaries of project intentions and outcomes from 6 student case studies

Table 8 implicates a transitional pathway from idea or intention towards resolution. In this case, this transition is a particularly large move, recounting the project across a full academic year through two particular points of engagement. Each student moves from initial ideas about the existing situation, as analysed in their early project development, and one year later, they present their design developments which are outline how they understand their prototypical
object participates in constructing a preferred situation (Simon, 1996). Each pathway is bounded in a similar way as a result of a common programme structure and pedagogical format, however, there is significant variation across the student projects themselves. Design narratives are clear in each component of coursework under examination, and a trajectory from initial idea across towards final proposition is clearly seen in each student case. However, the analysis of these three points of coursework content alone across our multiple-case study should be cautiously interpreted. Through discussions of various projects involving an interactive doll, a political boardgame, a bamboo skateboard or an additively manufactured prosthetic limb, we can see clear design project narratives which highlight how students have engaged in actions to improve the existing situations with new artifacts. However, the narratives in the design books are edited outputs themselves, stories centred on ways in which students have applied design practice to improving the existing situations with object interventions. Examining how this narrative, as output, has developed or evolved will require some examinations of student reflections on the process, which may highlight their critical understanding of decisions about actions which have led to these outputs.

The summary in Table 8 of the final design books might be also be summarised as a design story, in narrative form. As an example, Grasshopper Skateboards involves the production of a sustainable skateboard. The story of the design project, outlined in the design book, outlines how the board came into development, but it also implicates a why within a larger set of temporal events. Ambitions include the use of more renewable, more environmentally friendly materials. Consider the following summary, structured around a set of observed clauses which encapsulate the story of an existing skateboard:

- a maple tree, which takes a lot of effort and time to grow, is cut down, turned into lumber and veneer, and made into a skateboard
- the skateboard is purchased by a consumer
- the skateboard is used by the consumer
• the skateboard, during use, is broken by the consumer
• the broken skateboard is discarded into landfill and replaced by the consumer.

BL describes this linear process from tree, to skateboard, to waste, and defines a perspective about sustainability that involves addressing this “material ecosystem” by using a different material, namely bamboo. The sets of clauses outlined above are be rewritten from the view of the new, bamboo skateboard, beyond the story of its development within the project:

• a bamboo tree, which grows quickly and is easily harvestable, is cut down, turned into lumber and veneer, and made by our designer into a bamboo skateboard
• the skateboard is purchased by a consumer
• the skateboard is used by the consumer
• the skateboard, during use, is broken by the consumer
• the broken skateboard is discarded and replaced by the consumer.

In this encapsulation, BL has identified a number of maple skateboard products in existence which operate as predecessor artifacts (Morch, 2013) to help frame the challenge in his project development. However, to his understanding, no bamboo skateboards exist and this provides him with the basis of a design project, which addresses two key points associated with project-based learning (PBL), namely the development of a critical question and an opportunity to concretize their response to the question, as outlined in the literature review by proponents of PBL (Blumenfeld et al., 1991, Dym et al., 2005). It also provides him with the necessary doubts, ambiguities and uncertainties, operating as prompts for reflection (Dewey, 1933) as he begins to find a way to construct a prototype skateboard, made from bamboo, and helps to frame the story of the skateboard through project development.

These type of story constructions can be extrapolated from all the student design projects because, I argue, this is the actual purpose of the design books, the prototypes and the presentation materials communicating to a wider audience. The story of the project becomes a narrative through the selection of particular events by the narrator (Riessman, 2008), strung
together in order to communicate not only the project happenings, but to frame them in a manner which indicates to the audience that the project is an exemplar of a successful design project. The other project design books do something similar. Comiconnectors, for example, presents a story of the relationship between kids and their parents and the technological divide causing detachment, whereby the characters and dolls being designed use sensor technologies in a way to facilitate fostering healthy attachments whilst growing independence. Rapid Prosthetics questions the production process of the traditional prosthetic hand, based on a patent over 100 years old, and the inflexible nature of customisation, proposing the design of a new prosthetic using contemporary additive layering manufacturing techniques, which also afford users of prosthetic devices flexibility and personalisation through rapid and flexible manufacture. In all these instances, we see stories of product design projects that have resulted in the realisation of an object, which is engaged or acted upon in some future space and time, by various subjects.

4.4 Analysis: Narrative Transitions

At the onset of our thesis, 4 major themes were identified that allowed us to consider our research question, seeking to understand what conversations about projects during design tutorials might reveal about the richness of design. Though the conversations held and the stories told within our case studies are all very different from each other in their area of application and their presentation of outcomes, it isn’t clear how difference is managed during the project, during design practice, involving multiple stakeholders building consensus over goals and plans. Despite the different stories presented, they share many general characteristics, all predicated around a story or narrative grammar (Halliday, 1961, Labov, 1972), based on the transition from one set of events outlined as a problematic, to another set of events in the future where a new product becomes available that enables a different
approach, interaction or perspective, or makes things better. To examine our hypothesis more clearly, some analysis of this general narrative structure derived from these projects will be useful.

In the previous section, through deconstructing the Grasshopper project into a story predicated on a set of events under examination, we made a move to simplify the design document into something slightly more abstract. The abstraction was applied to Comicconnectors and Rapid Prosthetics projects as well, but was not abstracted enough to provide a general framework which might be understood as a foundation of all the product design projects collectively. If we consider that a student project (P) involves a narrative (N) under transition, I suggest that this a first step in deconstructing, or decomposing the concept of a project into smaller components. This process of decomposition regarding the project (P) might be illustrated in the following manner:

$$ P(N) \rightarrow \Delta N $$

Figure 19: Notation Describing Decomposition Of The Project

The right arrow in the equations above indicates a binary relation between the term on the left, and the sequence of terms on the right, suggesting that the left term can be decomposed into other various constituent parts. In this rewriting or decomposing the concept of "the project", which involves a transition in narrative, $ \Delta N $ is understood as "change in $N"$, a transition between the original narrative ($N_0$) towards the new narrative ($N_n$), which conventionally can be decomposed (rewritten) as follows, in Figure 20:

$$ \Delta N \rightarrow N_n \setminus N_0 $$

Figure 20: Narrative change, understood as the difference between a new narrative and the original one

In this notation, we suggest that “change of narrative” involves some set difference between the old narrative and the new one, whereby some action or production has been brought to bear
to make the set difference possible. As discussed in Chapter 2, adopting the position of Kress (1989a, 1992, 2010), we might suggest that every articulated narrative is somehow new, and new narratives emerge (like all other texts) as a result of difference, seen above as $\Delta N$. The position is illustrated in Figure 21 below, highlighting the project as a layer of operation, involving the changing narrative as some set difference between an existing narrative(o) and a future narrative(n).

![Diagram](image)

**Figure 21**: An illustration of a Project decomposed highlighting set difference between narratives

### 4.5 Summary

Having examined the case studies involving product design students engaged in project-led approaches, inspecting aspects of reflective activity and the role that narrative plays as a part of the overall project, what emerges is less about the particular narrative of experience themselves, as the mechanisms associated with a project as a site of narrative transitions, from the current narrative exemplified by an object type (in use by an identified subject) through to a preferred narrative, driven by some change. This is understood to some extent by decomposing the project into the transition between the two narratives. However, these design books, as outputs, are not dynamic and are constructed from the position of a student narrator, reflecting on and compiling their experiences to tell a particular story. The diagramme in Figure 21 provides us with a way to break the project open into the seeing the narrative
transition structure, seeing difference between the two narratives associated with the project transitions.

However, the macro-level case studies of student projects provide a blunt overview of this narrative structure, but little understanding of the mechanisms associated with managing the difference ($\Delta N$) involved in the transition at the micro level interactions. With our perspective situated in language and discourse, we return to Kress’ view (1989a, 1992), cited earlier, that difference is the driver of text, and without difference, there is no text. With this perspective of difference in mind, looking for mechanisms of difference, of narrative transitions, might be well served by examining more “on-the-ground” activities, such as the examination of events which comprise the narrative, which are accounted for and described in discussions during design development.

In this sense, the use of verbal reports as data (Ericsson and Simon, 1984, Ericsson and Simon, 1998), which are generated as a result of difference, might provide a clue about the moves being made to manage difference associated with the narrative transitions within the student projects. In the next chapter, transcripts of local tutorials are examined, which involve discussions in the intermediate process of design projects, as students and a studio tutor discuss their project development through prototypes and models, serving as intermediary devices and boundary objects (Star et al., 1989, Star and Griesemer, 1989, Vinck and Jeantet, 1995, Eckert and Boujut, 2003). This approach brings us closer to the design developments driving project progression, seeing the design actors engaged in actions, reflecting upon their experiences. Chapter 6 begins this work, moving from macro-level examination of project artifacts towards examining micro-level interactions situated inside the project, through analysis of tutor-student project tutorials.
To understand the dynamics of a project, it is relevant to consider the complete set of intermediary results (expected as actual) which marks out the trajectory and the history. These results are also mediators in the sense that they manifest and create a change in the state of relations between humans. They also have a specific built-in lifespan. Each mediating result creates a past and a future.

(Vinck and Jeantet, 1995)
5.1 Introduction

The case studies presented in Chapter 4 provide a rich source of data and insights about postgraduate product design projects undertaken over the course of an academic year. The chapter focussed on understanding the design, development and construction of objects, artifacts, and prototypes which support design narratives as part of the project scope within postgraduate product design education. Approaches and positions regarding project-based education were discussed in Chapter 2, contrasting perspectives to problem-solution orientations to design pedagogy, outlining narrative as an integral component of project-based design work, particularly within the educational setting.

The design project, as the site of examination, was presented as a complex, non-linear, set of processes showcasing design development, moving between initial intentions for action expressed by students in the earliest phase of their studies, through to the final propositional outcomes described and presented in their design books. The artifacts and objects under development, understood as prototypes, are normally presented as the final outcome of the project. These prototypes are considered as an embedded component within the overall narrative the design student is aiming to construct, which highlights aspects of future interactions with the potential end users.

5.1.1 Lessons learned from case studies

A macro level perspective of the project based on content analysis between initial proposals of student project briefs and their final design book highlighted narrative transitions at a macro level, but offered little insight regarding detail on how the narrative transitions are taking place.
As Vinck helpfully points out in the opening quote to this chapter, it is necessary to examine the intermediate steps inside a project to clearly understand how the project develops, but also how these intermediate steps are, in principle, also shaping the course or trajectory of the project itself. In our case study analysis of the coursework materials, the design books which accompany the final design prototypes provide post-hoc accounts of the project and associated processes, through descriptions of objects, prototypes, materials and techniques employed to arrive deliver the design solution. However, this approach provides little information about the project development, trajectory or evolution, in the absence of the intermediary steps which brings us there. In Chapter 5, a micro-level examination is employed engaging the content of intermediary tutorial interactions which took place over the course of the project, particularly in the development stage in the studio involving material construction of prototypical objects and artifacts, in order to determine specifically how these narrative transitions take place, through reflections on difference.

To understand students’ reflecting on difference and its relationship to narratives in transition within design projects, it is proposed that a closer examination of the design activity might be useful. This perspective allows us to deepen our examination with more granular detail associated with activities shaping the transition at intermediate points in time. If Chapter 4 concluded with the proposition that a design project involves transitioning from the current narrative, towards a new one, where addressing difference moves the project between two narratives, then Chapter 5 outlines an attempt to understand the transition in observing the intermediary steps in the project and decomposing the protocols of the tutorial interactions into their constituent parts to examine the nature of the design moves involved.

In Chapter 4, the coursework submissions under examination which are shaped, edited and constructed through students’ reflection on the experience associated with local decisions made across the project are a particular type of text. In these texts, the messiness of designing,
approach associated with “seeing-moving-seeing” as Schön describes it (1983, 1992) has been smoothed over to present a rational, post-hoc account of the actual design process undertaken. Project descriptions provide a clear account about the narrative transitions, but the uncertainty, doubt and ambiguity that is addressed, often comprising the core of design work in the moment, has been glossed over.

By contrast, tutorials in the studio involve verbal accounts of participants in the session, engaged with objects and actions associated with prototyping and design development, as the situation is unfolding. These interactions are often messy and unstructured, but provide the foundation of the overall design book based on the student designers’ experiences, captured as post-hoc accounts of those experiences. These verbal accounts in the tutorials involve turn-taking conversations, which can be understood as another type of text, distinct from the design books in form, structure and purpose. In sociolinguistic terms, all texts arise through difference (Hodge and Kress, 1995, Kress, 1992). Kress describes the position as such:

> Most speech genres are ostensibly about difference: argument (differences of an ideological kind), interview (differences around power and knowledge), ‘gossip’ (difference around informal knowledge), lecture (difference around formal knowledge), conversation. (Kress, 1989a)

Employing the tutorials as intermediary events in the generation of project texts allows us to pursue our examination of narrative transitions, through reflections on difference, using the methodological application of protocol analysis (Ericsson and Simon, 1984, Ericsson and Simon, 1998). As outlined in Chapter 3, protocol analysis has seen broad adoption within design research, where the fundamental assumption is that designers’ talking out loud, explaining their problem-solving approaches when engaged in design activity, is a valid manner of understanding how designer’s think and address ill-structured, open-ended problems (Simon, 1973, Goel, 1992, Perry and Sanderson, 1998).
Chapter 4 concluded by proposing that a design project might be defined as an approach to transitioning narratives, from an existing narrative to the proposal of a preferred one. Narratives were further decomposed into a sequence of events. Events, identified as a type of textual clause found readily at the level of the sentence, was decomposed into subjects engaged in actions, often with objects (or other subjects), situated in a time and place. This approach to narrative and events within the narrative frame was discussed in Chapter 2, where scholars of narratology and narrative inquiry (Todorov and Weinstein, 1969, Labov, 1972, Greimas and Porter, 1977, Franzosi, 2010, Riessman, 2008) were introduced.

Chapter 5 picks up the examination of the product design projects, the site of narrative transition, by decomposing the tutorials into the event clauses, and subsequently further into the constituent components of the events. Decomposing the transcripts into these constituent parts, linking related parts across the transcripts to examine the evolution of the conversation in the tutorial, is proposed as a method for interrogating the intermediary steps in the overall project development, thereby potentially providing better insight into the mechanisms involved with narrative transitions, through reflections on difference.

5.2 Design tutorials

Drawing insights from the case studies of student projects with such few data points has, so far, provided a challenge in addressing our thesis examination and our research question. Closer inspection of the projects in progress is possible in examining the discursive activities between the studio tutor and the students over the course of the semester. In this section, the studio tutorials between students and their tutor comes under scrutiny to understand how narrative transitions, as part of the student design projects, unfold during design development in the product design studio. Approaches to managing verbal reports as data, based on the
decomposition of transcripts of conversation, or talk-in-action, are discussed and employed, including linkography, node-link analysis, natural language processing and qualitative coding practices associated with discourse analysis. The rational for the adopting this approach, as well as the methodological challenges, are outlined and discussed at the end of the section.

5.2.1 Design tutorials: intermediary project events.

Within the studio project, particularly in education, a number of events take place which provide a space for feedback loops, when employing an action science frame of the project-based teaching. Tutorials can take a number of forms, but predominantly provide an opportunity to reflect on actions taken, leading to future action planning.

The pedagogical imperative in the studio environment is to foster experiential learning, or learning by doing (Dewey, 1933, Kolb, 1984, Schön, 1985). This perspective also highlights a number of activities which are associated with learning to design which are embraced in the studio environment: activities of analysis are developed through problem setting and scoping; synthesis occurs through constructionist propositions of making (in its broadest sense); evaluation takes place in formative feedback, as well as summative assessment as part of meeting educational institutional requirements. Feedback is offered as a formative tool by which students can reflect on their work experiences with studio tutors and staff. For some, the studio education model, particularly for architecture, is the preferred approach to teaching and for students to learn the practice of the discipline (Goldschmidt et al., 2010); others are more critical of the approach when viewed from outside the predominantly western tradition (Coetzer, 2010, Pasin, 2017).

There are no formal guidelines for how to give feedback, and approaches to managing tutorials in design studios are various. In the subsequent sections in the literature review, I outlined the
emphasis on discursive activities such as dialogue and conversation in many aspects of the
studio experience, particularly tutorials. In these sessions, a dialogic approach to feedback
takes place (Scagnetti, 2017), normally through recurring critiques throughout the academic
year.

Oh et al (Oh et al., 2013) outline 2 dimensions across which feedback is given: from informal
to formal, and from private to public. They outline 4 types of feedback event being evident in
the studio, ranging from individual "desk crits" (informal; private) through to group critiques;
interim review and finally formal review (formal, public). The authors comment that despite
the prevalence of this form of feedback and directive guidance, very little is known about the
critique. Uluoğlu (2000) presents a model of the critique as a complex system where different
forms of design knowledge are communicated and exchanged between studio masters and
students, resembling an information processing approach. Adams et al. discuss the various
roles adopted by tutors and instructors when operating within design reviews and studio
critiques, facilitating between adopting roles as coach, critical friend, and sometimes design
director (Adams et al., 2016b). Though the critique may be valued by reminiscent educators
or enthusiastic researchers, the event is often perceived as humiliating, counterproductive and
painful by students involved in the public form of the event (Elkins, 2001, Verhoeven, 2012,
Scagnetti, 2017). Some scholars, particularly those based in educational theory, are also
critical of the emphasis on fostering reflection without a clear understanding of what is meant
by the terminology (Kinsella, 2003, Russell, 2013).

In this study, various forms of feedback and engagement between students and tutors were
witnessed and recorded throughout the academic semester. Those events which are more public
in orientation (reviews, group critiques) were difficult to capture, described as performative
events (Dong, 2009a, Verhoeven, 2012) and, in an educational context, they are intended to
fulfil requirements for assessment, fostering a different and sometimes unintended
performative, towards approval and positive assessment, rather than the development of learning or reflective practice.

For these reasons, our study has selected to focus on the private and informal setting of tutorials in the studio, a situation where the design tutor and the student are reflecting on the works in progress and the past events which have led to their creation. Though these are sometimes referred to as 'desk crits'; the institution where these interactions are recorded has a dedicated space within the studio called "the crit space", presented at Figure 12, where tutorials can be conducted in relative quiet, away from the general bustle of the studio environment, enabling clear focus on the discussions about the artefacts under consideration.

In this frame, the tutorial is not necessarily a site where design is taking place. Rather, the tutorial is an intermediary event where past activities are reflected upon, in light of presented outcomes (the prototypes), and future actions are postulated. In these sessions, the tutor is adopting a role akin to a critical friend, or a coach, as discussed by Adams et al. (2009, 2016b, 2016a), engaging the student in collectively reflecting on intermediate progress of projects, leading to outcomes. In a product design studio, this often involves plans and drawings as well as physical artifacts and constructions. Morch (2013) discusses predecessor artefacts as prompts for conversation in a process-oriented, rather than a product-oriented approach to designing. Bowen’s discussion of critical artefact methodology outlines the ways in which ambiguous objects, when presented, prompt critical reflection (2009) rather than evaluation of problem-solution spaces. In both these studies, the artefacts operate as intermediaries in the project, as a goal-oriented trajectory (Gero and Kannengiesser, 2007), where past events, leading to the current state, come under scrutiny. The objects the students bring to the tutorial operate as traces of events and processes in their design projects, in the sense post-structuralist philosophers invoke the term (Derrida, 1976).
The conversation and feedback which occurs during the session are provoked by the interrogation of these traces. The tutorial, as a session, is a reflective event where the tutor and the student look back to the past events, not only to ascertain their value as experiences and shaping of personal values and governing principles. Design tutorials, it is argued, are opportunities to collectively reflect on design practice and project development. There may be evidence of reflecting-in-action (Schön, 1983, Schön, 1992b), but tutorial conversations are situated in a form of concurrent verbalisation about the retrospective experiences regarding the design events undertaken since the previous tutorial, describing the events that unfolded and the evaluation of the event outcomes as they help to progress the overall design project within the turn-taking approach to conversation.

Physical objects, materials, drawings and prototypical constructions are also present in these tutorial sessions. These artifacts play in bridging different worlds when operating in transitional events, either as inscription devices (Latour and Woolgar, 1979); boundary objects (Star et al., 1989, Star and Griesemer, 1989); conscription devices (Henderson, 1991); or intermediary devices (Vinck and Jeantet, 1995). These descriptions imply that objects, artifacts and drawings are involved in meaning-making processes in various ways, and allowing knowledge and viewpoints to be exchanged between people who are engaged in the exchange of such objects. Star outlines that when things operate as boundary objects they facilitate interpretive flexibility, they allow for the flow of information leading to the organisation of work processes, and that they are constructively ambiguous, allowing for interpretation to be dynamically moving between ill-structured understanding and custom application of the object in question. In Vinck’s terms, these intermediary devices, such as prototypes in the engineering process, allow for work processes to be mediated or commissioned, in either an opened, or closed manner (Vinck and Jeantet, 1995, Vinck and Blanco, 2003). In open circumstances, the intermediary devices provide multiple pathways of progression, whereas closed circumstances
provide one pathway only. Mediated pathways are those which are diversions from the anticipated workflow trajectory leading to the goal; commissioned pathways are those in which the anticipated workflow pathway towards the goals is supported and maintained.

For our purposes, once artefacts that students are developing are introduced to the tutorial, they operate both as boundary objects in space, as well as intermediary devices, through time. In both circumstances, the artefacts in question, when operating across various actor worlds, are provocative devices; for the student, they represent a summary of synthetic activities, now inscribed in the device. For the tutor, this synthetic activity of the other presents doubt and provokes questions while presenting difference. Difference is made manifest through the tutorial conversation through the turn-taking process. If the logical premise above is followed, design as a reflective activity involves managing this doubt, these provocative differences, as actors take turns negotiating the external world they share in the present, with the internal worlds shaped by their respective past experiences, their interpretations of the present, and ambitions or beliefs about futures. Employing tutorials as a form of protocol, where design moves are being employed to address difference in the tutorial space, allows us to employ protocol analysis as a method of examination.

5.2.2 Projects in Progress – student tutorials

The transcripts of tutorial interactions between student and tutor, generated from audio recordings of semester 2 interactions, differ from the other generated texts already examined. These include the original proposal submissions, the design book texts, the reflective statements, as well as the myriad of prototypes constructed and presented at the end of the programme. Conversational discourse involves turn-taking amongst participants, and as such, involves more responding in the moment to the remarks made by the speaker. What emerges is arguably are utterances and responses which are more indicative of thinking in the moment
about experience. As we already mentioned, Ericsson and Simon (Ericsson and Simon, 1984, Ericsson and Simon, 1998) differentiated between two forms of protocols when dealing with verbal text as data - retrospective and concurrent - and the texts earlier examined have already been discussed as retrospective texts, whereas these tutorial transcripts are more aligned to concurrent verbalisations.

If the nature of these conversational tutorials is concurrent verbalisation, then we might understand them as protocols, and subject them to similar analysis as other types of protocols, using similar tools. Moving towards an examination of the more localised design moves, discussed and reflected upon in conversational tutorial interactions between tutor and students, a “common sense” approach was adopted in the development of an in vivo coding scheme in order to construct linkographs, outlined earlier as a particular approach to studying design activity through protocol analysis which linked actors, actions, objects and materials, as well as places and spaces, across the verbal exchanges. The scheme was in part derived from the observation of the retrospective reflections when understood as a form of narrative on experience, where the project being described is predicated on proposing a narrative transition. Decomposing the narrative into events, and further into subsequent constituent parts of subjects, actions, objects, places and time, as done at the conclusion of Chapter 4, provides a useful start to building an in-vivo coding scheme allowing for examination of the transcripts.

This in-vivo coding scheme provides a "common sense" approach to coding the tutorial transcripts (Goldschmidt, 2014), without having to construct a separate and distinct coding scheme, employing the perspective that spoken language itself is already such a system (Franzosi, 2010).

5.2.3 The linkographs
This section outlines the first steps made to employ the grounded, "common sense" approach (Goldschmidt, 2014) to coding the continuous data in the verbal transcripts into discrete data, required to generate a linkograph and identify patterns of design moves. The ambition is to determine how design students are reflecting and acting on difference which arises through the . A section of transcript data from the initial tutorial between BL and the tutor is presented below, to help outline the steps employed to formalize the “common sense” approach to this task.

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>BL</td>
<td>This is skateboard.</td>
</tr>
<tr>
<td>16</td>
<td>TTR</td>
<td>This is decking for...this is the material for...from your skateboard?</td>
</tr>
<tr>
<td>17</td>
<td>BL</td>
<td>That's for like what the proper make-up of the skateboard is ...</td>
</tr>
<tr>
<td>18</td>
<td>TTR</td>
<td>Okay.</td>
</tr>
<tr>
<td>19</td>
<td>BL</td>
<td>...from the company in Canada, where the materials I'm getting.</td>
</tr>
<tr>
<td>20</td>
<td>TTR</td>
<td>Yeah. Okay.</td>
</tr>
<tr>
<td>21</td>
<td>BL</td>
<td>That's one I made myself.</td>
</tr>
<tr>
<td>22</td>
<td>TTR</td>
<td>From bamboo and...?</td>
</tr>
<tr>
<td>23</td>
<td>BL</td>
<td>Bamboo and with maple.</td>
</tr>
<tr>
<td>24</td>
<td>TTR</td>
<td>Yeah?</td>
</tr>
<tr>
<td>25</td>
<td>BL</td>
<td>Cross-grain.</td>
</tr>
<tr>
<td>26</td>
<td>TTR</td>
<td>Yeah?</td>
</tr>
<tr>
<td>27</td>
<td>BL</td>
<td>It's very strong.</td>
</tr>
<tr>
<td>28</td>
<td>TTR</td>
<td>Is it?</td>
</tr>
<tr>
<td>29</td>
<td>BL</td>
<td>Weighs the same, roughly. I was using this...what SK had.</td>
</tr>
<tr>
<td>30</td>
<td>TTR</td>
<td>So you've been weighing it? Okay. So that's what, 25 grams maybe? Yes it's about the same.</td>
</tr>
<tr>
<td>31</td>
<td>BL</td>
<td>About the same.</td>
</tr>
<tr>
<td>32</td>
<td>TTR</td>
<td>But what's the strength, the strength?</td>
</tr>
<tr>
<td>33</td>
<td>BL</td>
<td>I think bamboo is stronger.</td>
</tr>
<tr>
<td>34</td>
<td>TTR</td>
<td>How do you know?</td>
</tr>
<tr>
<td>35</td>
<td>BL</td>
<td>Stood on it.</td>
</tr>
<tr>
<td>36</td>
<td>TTR</td>
<td>Huh? (Laughter) Stood on it? (Laughter)</td>
</tr>
<tr>
<td>37</td>
<td>BL</td>
<td>I have to test it like, you know, properly.</td>
</tr>
<tr>
<td>38</td>
<td>TTR</td>
<td>Okay.</td>
</tr>
</tbody>
</table>

Figure 22: Transcript excerpt from Grasshopper Skateboards, Session 1; L15-38
Each utterance within the transcript contains a variety of words, doing different tasks. There are objects being presented, technical processes being outlined, geographical locations and other actors being discussed and materials, both instances, properties and attributes, being debated. In order to ascertain whether there are any connections between utterances being made, the premise is adopted that suggests that if a reference to something appears across two utterances, then these utterances can be linked, since some relationship to referential meaning is being exchanged between speakers. Four steps were followed in building the node-link dataset, through this assumption of the appearance of various words within utterances.

*Step 1: Find things.* Each utterance contains a set of referents – the things being discussed. How are each of our speakers making reference across the transcript to the other things within the space in their attempt to relate a holistic understanding of this object world? In the example transcript above, we see at L15 that BL introduces an object called “skateboard”, but at L16, the TTR appears to clarify that this is “decking”, a component of an entire board under scrutiny. Under linkographic construction, a line is drawn which suggests L16 is connecting L15 based on the relationship between something being discussed. L17 continues the thread between TTR and BL about his object, as BL clarifies that the reason for presenting the decking is to outline the material composition of a skateboard deck being examined. The discursive exchanges focusses the eye of both participants as we move from object through to component, through to composition. L17 is understood as linked to both L16 and L15.

Things which are being connected may involve physical artefacts which are under examination during the episode based on reflections in action, by student. In general, these things may be other people (i.e. L29 – “SK”) or geographical places (L19 – “Canada”), or any other type of noun being uttered by each speaker during their speaking turn.
Step 2: Find actions. At L21, BL introduces a second object, and differentiates it from the first (“the decking”) by outlining it as one “made” by him in the workshop. These actions provide us with particular components of the utterances which allows us to examine shifts in topic not by referents in the scene, but by actions undertaken to modify the evolving scene.

Verbs are parts of speech which involve actions in some way, but merely linking verbs misses the nuances of the kinds of actions taking place. BL’s reference in L21 to “…made…” can be related to other, more specific action types. Making may involve construction and assembly, but it may also involve reductive forms of activity, such as carving or sculpting. Within the context of the term, hierarchies of classes exist, and linking actions requires some degree of common sense. Within the transcript at L37, BL outlines another action “…test…”, and within context, the relationships between actions needs to be considered, before any link between utterances can be put in place.

Step 3: Find relations. At line 22, the TTR asks for clarification about these actions outlined by BL, regarding which materials have been brought together (L22 - “bamboo”) in the making of this other deck. Some technical terms about processes (L25 - “cross-grain”) follow, and a statement about desirable properties (L27 – “It’s very strong”; L29 – “weighs the same”) are outlined. In this sequence, links can be made back to the utterance by the student at L17 regarding his actions, as these subsequent utterances (L22, L25, L27, L29) all refer back to the results of the actions undertaken.

Step 4: Construct a linkograph. The linkograph is drawn as a set of lines between linked utterances, where one utterance may be related to several previous utterances, depending on those subjects, objects or actions that are made reference to within respective utterances. The linkograph is easily numerated in a spreadsheet, where each line number (the utterance in the transcript) is followed by the line references to earlier related utterances. This method of
constructing “backlinks” [Goldschmidt] through the transcript will eventually reveal “forelinks”, which are seen as markers about utterances which may be highlighting future design actions and events, signalling potential importance of these utterances as “critical moves” (Goldschmidt, 2014).

LinkOder was the application used to generate the visual linkographs from the node-link matrices generated through a common sense approach to coding. The tool was developed in Processing, and runs in the Java framework in a cross-platform environment. The application was developed by Pourmohamadi and colleagues (Pourmohamadi and Gero, 2011) and can compile detailed statistical information from linkographic datasets, easily constructed in various spreadsheet software packages.

Appendix 1 presents 7 linkographs, constructed from the coding of 7 sets of tutorial transcripts from three student project cases under detailed examination in Chapter 5: Grasshopper Skateboards (BL2), Rapid Prosthetics (RC1), and Comicconnectors (CT1). These linkographs were generated using datasets constructed from the heuristic outlined above, making relational linkages between parts of speech found within each utterance across the respective datasets.

Below in Figure 23 is an extract of the first linkograph generated from the tutorial transcript of the first session between BL and the studio tutor.
There are a number of reasons why the use of linkography should be critically questioned as an appropriate method applied to the transcripts of tutorials presented here. The tutorials are different than standard protocols used in examining design reasoning and thinking in four key areas.

First, there are limitations to the value of the software employed in our current situation. The application LinkOder was devised for a specific purpose and supports a particular view of cognitive design processes based on Gero’s FBS ontology (Kan and Gero, 2005, Gero and Kannengiesser, 2007). The application itself is helpful in quickly generating a visualised graph, which clearly outlines clusters of activity related to design moves through forelink and backlink relationships across the transcript (Goldschmidt, 1990, Goldschmidt, 2014), but analysis and quantified measures produced by the software are based on particular relationships found within the dataset based on a bespoke coding scheme constructed from within the FBS.
framework, and returning specific measures in line with a particular theoretical perspective associated with design activity examination through protocol analysis.

Second, the visualised linkograph is an arc-diagramme construction, one particular visual approach to network graphing among many. However, without customisation, LinkOder is unable to differentiate between speakers, and distinguish between attributes of speaker utterances, beyond being coded for their cognitive themes under the FBS framework. This provides a challenge in understanding the impact of the utterance by one speaker, in relation to a response by the other person in the tutorial exchange. The inability to differentiate between speakers may be problematic in understanding how narrative transitions are taking place at the event level. Though relational constructions are easily possible within linkography, multiple referential considerations are difficult under the software as provided.

A third challenge the tutorials under examination can be considered a form of concurrent reflective discourse, based on retrospective accounts of experiences in the student design project. However, it is unclear whether the tutor and the student understand the project in the same way. A prime assumption in linkography is that the design task being undertaken is a collective one, whether the design activity under examination is done by a single designer, or a team who are acting as a "team of one" (Goldschmidt, 1995, Valkenburg and Dorst, 1998). To that extent, little opportunity exists to differentiate between speakers identified in the transcript, or whether they are collectively engaged in a common design task. It is arguable whether a studio tutor and a design student engaged in a conversation about student project work might be considered a “team of one”, given the distinctiveness of their roles and whether they are engaged in the same task, through the student’s project.

A final criticism of linkographic techniques has to do with the reliability of the coding exercise itself, after the protocol has been linked in a “common sense” way. Coding schemes like the
FBS framework from Gero and colleagues (Gero and Kannengiesser, 2007, Kan and Gero, 2008, Tang et al., 2011) are generally not circulated beyond the projects which employ the scheme. Coding schemes themselves are generally specific to a particular research perspective or question (Saldaña, 2013). Coding, as a qualitative practice, is strongly associated with grounded theory (Corbin and Strauss, 1988, Strauss, 1993, Charmaz, 2006), where the activity involves constructing theoretical perspectives of circumstances from within the data captured in the research. Driven from the bottom up, coding is done iteratively, and repetitively, to arrive at an appropriate localised theory of understanding and explaining particular phenomena within a limited research scope. Despite the attraction of a useful, abstracted framework which might be generated through coding schemes, they require constant interpretation and scrutiny, as well as modification, in the face of new data, and require validation through ensuring inter-coder reliability when multiple coders are involved in the exercise. This qualitative approach to theory construction has come under scrutiny, both in the domain of pedagogy and education (Bell et al., 2011), and perhaps more crucially within design research itself (Perry and Krippendorff, 2013).

In short, the studio tutorial is less about design, than it is about planning for design, and about learning. The discourse taking place here is situated in reflective narratives, rather than process reasoning and problem solving. The arc diagrammes constructed through LinkOder are able to visualise dense areas of activity based on relationships between entities under conversational focus, where critical aspects of the conversation are found in those utterances deemed to be most highly connected. Beyond this surface analysis, linkography provides little insight into the metaphorical analysis of design as a conversation with the materials of the situation.

5.2.4 Network Visualisations
The LinkOder application developed by Pourmohamadi et al (2011) was developed for a particular project, and has not been commercialised, nor provided to the design community under open access frameworks to allow collective development, maintenance and improvement.⁸ As such, the software is highly specialist and useful in specific circumstances, which may not be applicable to our theoretical position regarding reflecting on difference in narrative transitions as part of the overall design project approach. Despite this, linkography is predicated on the use of the adjacency matrix, a common format in graph theory approaches, and a multitude of other tools are available which can make use of node-link data to construct different types of graphs, beyond the arc-diagrammatic approach espoused by linkographic techniques.

There are a variety of tools freely available for the construction of social network graphs, a useful review of SNA software package is beyond our scope, but the review by Huisman and van Duijn (2011) is helpful. For our purposes, a decision was made to employ Gephi (Bastian et al., 2009), an open-source, platform independent and straightforward graphing application able to construct strong visualisations from adjacency matrices in .csv format.

The datasets which were generated in our purposes of constructing the linkographs, themselves in the form of an adjacency matrix, remain useful in developing social network graphs through widely available, community support and flexible software packages which provide wider statistical measures which are generally understood, and documented, more broadly than linkography. In particular, forelinks and backlinks, made visually apparent within the arc-diagrammes and summed within the LinkOder application, correspond directly to relations of degree under graph theory, specifically forelinks correspond to in-degree measure and

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⁸ Despite repeated attempts to contact the author and developer to volunteer personal time to improve and update this software, no reply was received and the source code remains unavailable.
backlinks correspond to out-degree. Converting to these more standardized measurements provides a novel frame.

More recently, social network analysis has been applied to narrative structures to ascertain insights about how narratives are structured and transmitted through conceptual and relational linkages (Jarynowski and Boland, 2016, Fernández-Aceves, 2017). With narrative approaches already reasonably established as a methodological perspective in the analysis of design tutorials (Adams et al., 2016a, Hutchinson and Tracey, 2015, Tracey and Hutchinson, 2016), and the similarities outlined above in the common-sense construction of linkograph datasets, the linkographs are substituted for social network graphs constructed in Gephi, providing flexibility in application through labelling of utterances by speaker, and constructing relations between utterances in various types predicated on the speaker making the utterance, as well as the previous utterances to which it was linked. Additional measures of centrality, and community clustering, also provide added tools for the examination of the tutorial conversations, allowing for more depth in analysis of the tutorial as a site of reflective conversations structured around earlier events.

Appendix 2 presents 7 interpretations of the linkographic datasets presented in section 5.2.3, constructed again from three cases under examination: Grasshopper Skateboards (BL2), Rapid Prosthetics (RC1), and ComiConnectors(CT1). These visualisations were constructed as social networks, employing the same node-link matrices discussed in the preceding section, using the same link data used to generate the original linkographs.

Below in Figure 24 is an extract of the first network graph, generated with Gephi, employing the same node-link adjacency tables from the linkograph exercise. Similarly to Figure 23, this detailed image is extracted from the tutorial transcript of the first session between BL and the studio tutor.
Figure 24: Detail of network graph using linkograph data from the first tutorial session Grasshopper Skateboards

The visualisations generated from the adjacency matrix constructed in the linkographic exercise through Gephi stand in contrast to the visual arc-diagrammes constructed under LinkOder in a number of ways.

First, clusters are more clearly evident in the node-link diagrammes constructed from Gephi, as opposed to the arc-diagrammes generated in LinkOder. These community clusters are identifiable when a network algorithm is applied to the underlying adjacency matrix originally constructed in linkograph exercise. Modularity scores range between 0 and 1, and a graph that returns a high modularity score is understood to have strong connections between nodes within communities, with weaker connections between nodes across communities. Descriptions and explanations of modularity algorithms, the mathematical approach to community clustering, are beyond the scope of this discussion, but a comprehensive account of the specific algorithm employed by Gephi can be found with Blondel et al (Blondel et al., 2008). The benefit of these clusters is that various related segments of conversation can be found, implicating that various
topics are under discussion within the tutorial frame (Botta and Woodbury, 2012). These various topic segments in our node-link graphs are identifiable by colouring related nodes, or utterances.

Second, the temporal timeline of progression through the transcripts is no longer visible in the Gephi graphs, as they are in the LinkOder arc-diagramme. This is a benefit of the linkographs over the SNA visuals in that the process of designing appears to unfold through time, highlighting clearly now utterances are linked across a temporal dimension.

Third, though the temporal timeline of the conversational discussion is evident in the arc-diagramme generated by LinkOder, the software is unable to visualise utterances made by the two different speakers, nor to ascertain the linkages between the utterances, highlighting whether the references by speakers are to their own statements, or their conversational partner. The node-link graph generated by Gephi is able to differentiate nodes in the graph by virtue of node attributes, outlining which node is an utterance by which speaker (tutor or student). By extension, the attributes ascribed to each node allow for visualising relationships between utterances, highlighting whether utterances made by speakers are connected to their own prior statements (back links) or those of the conversational participant in the tutorial scene.

Finally, the most significant difference between the arc-diagrammed approach to linkography and the node-link graphs generated by Gephi is the ready identification of central statements, through the generation of relevant metrics. Eigenvalue centrality is a graph measure derived from the adjacency matrix which identifies the relative importance (or centrality) of nodes within the overall network. Where linkography is able to identify critical moves by forelinks (out-degree) and backlinks (in-degree), centrality measures allow us to establish relative importance by also taking into account the degree to which a well-connected node is connected to other, well connected nodes. To that extent, centrality allows a measure to go beyond simply
direct reference, but provides a deeper measure of importance by association of a central node, and its relationship to other central nodes. A full explanation of eigenvalue centrality is better found in literature associated with graph theory (Freeman, 1977, Borgatti, 2005). For our purposes, the eigenvalue generated by Gephi can be applied to nodes to visual relative importance, and in our case, the largest nodes in our graphs are those which have the highest centrality value, considered central statements or critical moves in the overall design discussion.

A series of tables were constructed which present values generated from networking algorithms found in Gephi. This data is derived from the linkographic exercise, undertaken in Chapter 5, applied to the seven transcripts of interactions in our three case studies. The tables provide an overview of the nature of the interactions between the student and tutor.

The head of each table highlights the overall length of time of each interaction, nominally within the 30 min limit set for individual tutorials in the studio). The first column (Mod.Class) is an arbitrary number assigned to each statement in the transcript, leading to community clustering of connected nodes (utterances in the transcript). These clusters highlight strong relational connections between segments of text, which can be described as “tutorial topics” under discussion. The statements which are related are colour-clustered within each network visualisation diagramme in Appendix 2, the size of each topic is outlined in Column 7 of each table under Total Utterances. The Total Utterances is also broken down into the number of utterances made by each speaker (per Mod Cluster), indicating which speaker is taking conversational lead in particular topics.

Column 2 in each of these network matrix tables presents the maximum Eigenvalue Centrality value for each topic segment (Mod Class). Eigenvalue Centrality is a measure that highlights the most central node in a network, 1.000 being the most prominent, central node in the
network. Column 3 (At Line) highlights which utterance (by line in the transcript) generates this eigenvalue, providing an indication of the central statement of the topic. Column 4 is the identified topic under discussion, in each Mod.Class, derived from the statement which returns the Max.Eigenvalue in the Mod.Class. For instance, in Table 9, Mod.Class 3 returns a Max.Eigenvalue of 1.000 at Line 17. This statement, according to our network analysis, is the central statement in the overall transcript, made by the student, outlined in Figure 25 below:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>BL</td>
<td>That is for like what the proper make-up of the skateboard is …</td>
</tr>
</tbody>
</table>

Figure 25: The central statement from Grasshopper Skateboards, with Max Eigenvalue 1.000, within Mod.Class 3, highlighting a topic under discussion involving composition

A total of 7 tables (Tables 9-15) are presented below, one for each tutorial interaction recorded as part of our micro-level case study analysis. These tables have helped to rationalise decisions involving how to proceed in Chapters 6 and 7, narrowing our discussions to central topics, identified as the community clustering of statements around the statement that presents the highest eigenvalue, in that cluster. By extension, the Mod.Class that contains the central statement with a Max.Eigenvalue of 1.000 is considered to be the central topic of the tutorial interaction, under examination.
Table 9: Network Metrics from Grasshopper Skateboards (Session 1). Generated in Gephi

<table>
<thead>
<tr>
<th>Grasshopper Skateboards (2)</th>
<th>Tutorial duration (hh:mm:ss) -- 00:23:59</th>
<th>Utterances</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod. Class</td>
<td>Max Eigenvalue</td>
<td>At Line</td>
<td>Topic</td>
</tr>
<tr>
<td>0</td>
<td>0.555</td>
<td>4</td>
<td>Experiment – Hessian fibre which will be used as interlayer is applied as an outerlayer</td>
</tr>
<tr>
<td>1</td>
<td>0.273</td>
<td>37</td>
<td>Testing (1) – primarily for strength</td>
</tr>
<tr>
<td>2</td>
<td>0.328</td>
<td>41</td>
<td>Preparation – readying material for construction</td>
</tr>
<tr>
<td>3</td>
<td>1.000</td>
<td>17</td>
<td>Composition – examining how the object is actually put together</td>
</tr>
<tr>
<td>4</td>
<td>0.256</td>
<td>9</td>
<td>29</td>
</tr>
<tr>
<td>5</td>
<td>0.160</td>
<td>102</td>
<td>Stickling – as part of laminating, an intermediary material is required to which the main material won’t stick</td>
</tr>
<tr>
<td>6</td>
<td>0.277</td>
<td>137</td>
<td>Secondary material – strength and grip of adding third material (Jute) to the composition</td>
</tr>
<tr>
<td>7</td>
<td>0.105</td>
<td>184</td>
<td>Testing (2) – a grip/wear test for another material (cork)</td>
</tr>
<tr>
<td>8</td>
<td>0.049</td>
<td>227</td>
<td>Material thickness – how to engage the process most efficiently</td>
</tr>
<tr>
<td>9</td>
<td>0.215</td>
<td>233</td>
<td>Testing (3) – clarification of alternative approaches</td>
</tr>
<tr>
<td>10</td>
<td>0.049</td>
<td>213</td>
<td>Stakeholder – identification of others with specialist knowledge</td>
</tr>
<tr>
<td>11</td>
<td>0.022</td>
<td>299</td>
<td>Documentation – recording the process</td>
</tr>
<tr>
<td>blank</td>
<td>0.000</td>
<td>232</td>
<td>third party interaction - not included</td>
</tr>
<tr>
<td>149</td>
<td>156</td>
<td>305</td>
<td>247</td>
</tr>
</tbody>
</table>

Table 10: Network Metrics from Grasshopper Skateboards (Session 2). Generated in Gephi

<table>
<thead>
<tr>
<th>Grasshopper Skateboards (3)</th>
<th>Tutorial duration (hh:mm:ss) -- 00:28:45</th>
<th>Utterances</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod. Class</td>
<td>Max Eigenvalue</td>
<td>At Line</td>
<td>Topic</td>
</tr>
<tr>
<td>0</td>
<td>0.338</td>
<td>2</td>
<td>Material - qualities: grip tape after laminating (sticking)</td>
</tr>
<tr>
<td>1</td>
<td>0.700</td>
<td>51</td>
<td>Material (2) - properties and composition maple/bamboo</td>
</tr>
<tr>
<td>2</td>
<td>0.179</td>
<td>58</td>
<td>Preparation – materials prepped and ready, w. PK</td>
</tr>
<tr>
<td>3</td>
<td>0.002</td>
<td>98</td>
<td>Comments – affirmative</td>
</tr>
<tr>
<td>4</td>
<td>1.000</td>
<td>29</td>
<td>Testing – with external professional RP</td>
</tr>
<tr>
<td>5</td>
<td>0.842</td>
<td>113</td>
<td>Testing (2) – strength</td>
</tr>
<tr>
<td>6</td>
<td>0.013</td>
<td>213</td>
<td>External discussion about class administration</td>
</tr>
<tr>
<td>7</td>
<td>0.000</td>
<td>225</td>
<td>Question – clarification (is not heard)</td>
</tr>
<tr>
<td>8</td>
<td>0.002</td>
<td>229</td>
<td>Reflective statement – like you said, have to wait</td>
</tr>
<tr>
<td>9</td>
<td>0.000</td>
<td>296</td>
<td>Comments - trailing</td>
</tr>
<tr>
<td>10</td>
<td>0.567</td>
<td>42</td>
<td>Materials (3) – bamboo, composition</td>
</tr>
<tr>
<td>11</td>
<td>0.902</td>
<td>11</td>
<td>Artefact - comparisons of construction and strength</td>
</tr>
<tr>
<td>12</td>
<td>0.002</td>
<td>363</td>
<td>Comments - affirmative</td>
</tr>
<tr>
<td>169</td>
<td>198</td>
<td>367</td>
<td>436</td>
</tr>
</tbody>
</table>
### Rapid Prosthetic (1)

<table>
<thead>
<tr>
<th>Mod. Class</th>
<th>Max Eigenvalue</th>
<th>At Line</th>
<th>Topic</th>
<th>Utterances</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.478</td>
<td>6</td>
<td>The Project - motivating, value of project is good</td>
<td>4 11 15 0 4 3 4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
<td>7</td>
<td>Planning - discussing future work plan; processes</td>
<td>20 14 34 73 18 12 18</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.373</td>
<td>42</td>
<td>Types of Foam - considering materials for building the prototype</td>
<td>16 13 29 15 18 20 18</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.167</td>
<td>60</td>
<td>Sourcing - trying to locate materials (CIBAtool) for prototyping</td>
<td>16 15 31 23 15 8 15</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.000</td>
<td>105</td>
<td>&quot;um&quot; - not relevant</td>
<td>0 1 1 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.158</td>
<td>100</td>
<td>Alternative printer - different ways of printing, machine with multiple materials (Vista)</td>
<td>4 10 14 0 7 0 7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.043</td>
<td>117</td>
<td>Intermediates; printing, testing properties</td>
<td>6 7 13 2 9 5 9</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.056</td>
<td>132</td>
<td>Finding support - help with Cibatool and digital tools - talk to stakeholder</td>
<td>9 8 17 3 14 8 14</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.053</td>
<td>148</td>
<td>Material properties - Blue foam vs Cibatool; Comparing benefits of both for prototyping</td>
<td>6 6 12 3 11 2 11</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.000</td>
<td>163</td>
<td>ambiguous sentence</td>
<td>1 0 1 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.040</td>
<td>180</td>
<td>Motivating - keep project going</td>
<td>4 8 12 2 4 4 4</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.146</td>
<td>11</td>
<td>Discussing Fabrication Contractors</td>
<td>16 4 20 30 6 10 6</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0.151</td>
<td>202</td>
<td>Explaining - atecchnical discussion about thread count/pitch for attaching prosthetic device to mount</td>
<td>15 16 31 8 29 10 20</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0.007</td>
<td>231</td>
<td>tutorial conclusion - affirmatives</td>
<td>1 2 3 0 1 1 1</td>
<td></td>
</tr>
</tbody>
</table>

**Table 11:** Network Metrics from Rapid Prosthetics (Session 1). Generated in Gephi

### Rapid Prosthetic (2)

<table>
<thead>
<tr>
<th>Mod. Class</th>
<th>Max Eigenvalue</th>
<th>At Line</th>
<th>Topic</th>
<th>Utterances</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.002</td>
<td>1</td>
<td>Scoping - posing a question confirming whether an action took place</td>
<td>1 1 2 0 1 3 1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
<td>3</td>
<td>Meeting the client, and feedback from him on the developments - expert user insights</td>
<td>19 19 38 12 35 12 35</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.665</td>
<td>9</td>
<td>Analysing - assessing form details of prototype and how they contribute to prototype performance</td>
<td>60 27 87 290 94 20 94</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.370</td>
<td>94</td>
<td>Analysing - assessing details of prototype; form and user activities; future actions</td>
<td>21 35 56 81 142 8 142</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.002</td>
<td>114</td>
<td>&quot;do you know what I mean?&quot; &quot;yes&quot; direct request to ascertain understanding</td>
<td>1 1 2 0 1 0 1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.432</td>
<td>21</td>
<td>Modifying - past construction/destruction activities of the prototype</td>
<td>20 37 57 26 29 0 29</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.000</td>
<td>149</td>
<td>Fragment - but if you do that ...</td>
<td>0 1 1 0 0 5 0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.017</td>
<td>223</td>
<td>Modifying - intended detail adjustments (a few mm)</td>
<td>5 4 9 10 7 8 7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.006</td>
<td>150</td>
<td>Modifying - speculative detail adjustment (if that piece)</td>
<td>1 4 5 0 1 2 1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.033</td>
<td>169</td>
<td>Clarifying - construction strategies (is it hollow?) This is related to process and structural affordances of construction</td>
<td>8 6 14 8 10 0 10</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.084</td>
<td>233</td>
<td>Interfacess - how the real device connects to the hand and the way the mechanism transfers to the prototype/future. Weak points</td>
<td>16 21 37 16 22 4 22</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.053</td>
<td>290</td>
<td>Economics - how much does it cost to print each copy? Value of testing. Side discussion of integrated features</td>
<td>10 11 21 22 23 10 23</td>
<td></td>
</tr>
</tbody>
</table>

**Table 12:** Network Metrics from Rapid Prosthetics (Session 2). Generated in Gephi
The metrics presented in these tables, which highlight central statements and topics of discussion within each tutorial, provide no semantic understanding of the context of the tutorial, or the utterance themselves. The measures generated are in strict relation to the number of connections (edges) between assorted statements, which is in turn directly connected
to the “common sense” coding scheme that has been employed in our linkographic exercise (Goldschmidt, 1990). A different coding scheme, which typifies statements into particular knowledge segments, types of design moves, or other premise, will deliver very different results, leading to alternative approaches to analysis and insight.

5.2.5 Natural Language Processing

In the previous sections, two approaches to graphing link-node matrices were presented, which arguably facilitate a quantitative perspective to the tutorial transcripts of student-tutor interactions when examining the narrative transitions as part of the student design projects, when narrative structures are decomposed into constituent components of subjects, actions and objects. The main shortcomings involved with LinkOder and Gephi may be in part due to limitations in the software, but there may also be some challenges to the activities associated with constructing a link-node adjacency matrix from conversational text. In this section, a process for uncovering information within text through computational decomposition is presented, involving the technique of Natural Language Processing, predicated on known language structures and involving language grammars and parts of speech.

Natural Language Processing (NLP) is a computational technique for allowing machines to manage transcribed textual structures, through decomposition of text based on syntactical features in the text. The approach involves a variety of methods and tools, based in computational tools such as the Python coding environment, which can facilitate an understanding of how talk is syntactically and grammatically structured, and through comparisons with a large dataset (a corpus), develop a structured outline of the text content. NLP employs decomposition of texts into unit parts-of-speech (PoS), and is able (to a significant degree) to address associations between various constituent parts. NLP employs a variety of algorithmic approaches to simplify text in order to make it more amenable to
computation, as well as constructing some sense of text based on word frequency, word position, as well as word types (i.e. negatives or positives). The strength of NLP lies in its ability to compare the text under scrutiny with a training corpus, and draw pattern insights through large datasets in making the comparison. However, the structure of the text under consideration requires a corpus of significant size and relevance in order to draw conclusions.

NLP has its roots in the work of Noam Chomsky and his work on syntactical structures and transformational grammars (Chomsky, 1957). Chomsky’s position regarding language was in opposition to that of Saussure’s approach with an emphasis on signification (Saussure, 1960), where he believed there was a general, underlying set of rules that governed how people used language to communicate effectively. The approach to decomposition of projects, outlined at the end of Chapter 4 is predicated on Chomsky’s approach to decomposition of a statement or sentence into constituent parts, where Chomsky focussed on the parts of speech in the sentence and their syntagmatic relationships to each other in order to convey meaning in the message. For Chomsky, a sentence (S) consisted of various phrases, nominally a noun phrase (NP) and a verb phrase (VP). Chomsky’s approach is illustrated below in Figure 26.

\[ S \rightarrow NP \ VP \]

Figure 26: Chomsky's structural syntax, rewriting a sentence into noun phrase and verb phrase

NLP has had significant implications and application in contemporary technical devices, particularly through voice-recognition support technologies. The use of text-mining from social media platforms provides a wealth of data regarding topics of interest and discussion within communities, allowing analysts to generate new insights and focus resources through sophisticated approaches to processing various forms of text found readily in digital form through our interactions with internet-based media applications and platforms. Advances in NLP approaches have moved away from simpler parts of speech towards employing parsing algorithms (Chen and Manning, 2014) which are able to identify and build relationships
between a root word in the sentence and the other constituent components within a sentence structure. A variety of tools to apply NLP processes are available, including the established Natural Language Toolkit (NLTK) (Bird et al., 2009) to the very sophisticated approaches to packages such as Stanza (Qi et al., 2020).

5.2.6 Summary: inter vs extra textual approaches to transcripts

In examining the tutorial transcripts from the Chapter 4 case studies in the manner that we have, the inductive coding scheme which was applied to each utterance discursive transaction during the tutorials highlighted our intuitive approach to understanding constituent parts in the narrative event, while our method for examining design moves through node-link analysis focusses on similarities between events, rather than difference. Node-link analysis can neither take into account syntagmatic constructions within sentences, nor paradigmatic potentials when making linkages at the surface level of sentences and utterances using parts of speech as the unit level of analysis. Narrative transitions are under examination in this thesis, and these involve some form of re-configuration based upon difference, as opposed to similarity. What appears to be involved with constructing linkographs, node-links, or employing other approaches to coding based on parts of speech as units of analysis involves an inter-textual set of relationships; that is, connections can only be made between what exists. This approach is also fundamental in NLP approaches to textual analysis, but in relationship to inter-textual analysis as compared to similarities found within the corpus on which the algorithms are trained. However, as outlined at the start of the chapter, our examination here is to understand how design projects under examination are being driven by narrative transitions, where some way of understanding the difference between two narrative states is critical to moving the design projects forward. Inter-textual relationships, we argue, are based on similarities, whereas difference, it is suggested, requires extra-textual consideration.
Micro-level examinations of the tutorial protocols suggest that turn-taking conversations regarding actions leading to a specific goal or purpose, present difficulties in design analysis if employing a graph-theory approach, such as linkography or network graphing. Furthermore, computational language-based tools, such as Natural Language Processing are equally problematic. These practices involve coding specific utterances within protocols as representing distinct design knowledge structures (Suwa et al., 1998, Gero and Kannengiesser, 2007, Goldschmidt, 2014), or they involve examining frequencies of parts-of-speech embedded within sentences, in relation to a shared corpus drawing insights from language structures (Dong and Agogino, 1997, Dong, 2009b). As outlined in the previous section, a key premise which underlies these types of examinations is the understanding that language, whether spoken word or drafted text, conveys information or knowledge which is pre-packaged and contained inside the utterance itself. In historical design protocol examinations, individual designers are articulating their inner thoughts in talk-aloud scenarios, where conversations amongst team members during collaborative design activity might actually be considered as "a team of one" (Goldschmidt, 1995). These studies engage language as a vessel through which cognitive activities of designers in action can be explored, but do so through understanding text as explanatory, and goal-related, either with individuals or teams.

By contrast, the tutorial interactions which are under examination in chapter 5 involve a turn-taking approach to conversation. This format of discursive interaction is predicated on the assumption that it is more than information that is being exchanged through language. Rather, meaning is conveyed through actions of discourse which involves perception, interpretation and then clarification, leading towards the development of shared understanding amongst participants involved in the discursive interaction. In this view, language is a tool which requires turn-taking in order to facilitate socially constructed understanding between members of communities, who may or may not be working towards common goals. The information
embedded within utterances may require local interpretation and clarification and understanding of others’ experiences, which led to adopting analysis of narratives as our frame for examination in Chapter 5.

Tutorials, it was suggested, are intermediary events where experiences shaping the design project are discussed, through conversations between participants. If stories about the projects involves a series of events temporally connected, narratives, by extension, were outlined as a sequence of particular events tied together, by a narrator, constructed for a particular purpose or disseminating a particular message, to an audience. The tutorials under examination highlighted various people, actions, places, artifacts and materials being discussed between the student and the tutor. These constituent parts-of-speech were easily uncovered in the grounded approach to coding adopted in the construction of linkographs and network graphs, since they are the syntactical foundation of discursive practices. They also correspond to the constituent components of events found within narrative structures, as discussed in Chapter 2, where scholars of narratology and narrative inquiry (Todorov and Weinstein, 1969, Labov, 1972, Greimas and Porter, 1977, Franzosi, 2010, Riessman, 2008) were introduced.

5.3 Analysis and Discussion

Despite the challenges highlighted regarding the ability of node-link analysis to uncover transitions across our tutorial protocols, based on turn-taking conversations, insights can be drawn. Notably, the very reason that our transcripts are not suited to node-link analysis may provide a clue. The structure of conversational interactions are premised on turn-taking, where new information and understanding are gleaned from a speaker’s statements, and where the listener reacts or responds to the insights presented. As outlined, the nature of conversations are often found out with the actual text itself, and often what is said isn’t actually spoken (Grice,
1989, Kress, 1989a), rather is in the relationship between utterances, between statement and response. In this final section of Chapter 5, we discuss these based on a structuralist approach to language which leads us to an initial framework of difference, preparing for a revisiting of the tutorial transcripts in Chapter 6 to examine narrative events, in a new light.

5.3.1 Commutation

In the conversational tutorials, what seems to be emerging are sets of narrative discussions which are operating around practices of commutation. Commutation has a long history in semiotics and semiology (Jakobson, 2010, Barthes, 1968, Chandler, 2007), and operates as a useful method for understanding how meaning is formed and exchanged within communication practices situated in language. Within the field of semiotics, at the level of everyday language use in context, commutation is a particular method to ascertain coherence of meaning by actively moving words around to ascertain reciprocity. In arithmetic, commutation is evident though practices of addition by changing the presentation order of numbers in an equation which results in no change in the result (i.e. $1+3 = 3+1$), whereas commutation is leads to problems when considering the practice of subtraction (i.e. $3-1 \neq 1-3$). These moves are equally applicable in the semiotic practices of signs and signification.

Chandler (2007) provides a most useful and accessible account outlining commutative practice with 2 primary move in addition and subtraction, with two supplementary moves involving substitution and transposition, these being special types of moves which involve combining both addition and subtraction in novel ways. Hébert & Tabler (2020) go further, adding two further operations of transformation including displacement and continuance, whilst highlighting that these 6 operators are based on extensity (on objects), whilst commutative transformations might also operate through degrees of intensity.
For our purposes, at this juncture in the study, we will start the observation that commutative practices, involving these particular semiotic moves in language, and their relationship to designing product prototypes, are less conducive to analytical examination using node-link approaches whereby units of analysis are connected based on characterisations and codes through association. Commutation, we argued, involves transitional shifts which involve a series of possible moves, leading to some difference, which is evident in the comparative analysis across units of analysis. In this observation, we begin our framework of difference with the understanding that student projects, when seen through a lens of narrative transitions, require one of these moves to be made, in order to produce difference and bring into focus, leading to a reply or counter response to clarify the difference present in the discursive space.

5.3.2 Structures of discourses

Using an in vivo approach to finding the individual words within a discursive statement, and linking utterances together which contain similar words is perhaps a naive method (at best), when trying to understand narrative transitions as part of the design project in process. This, in part, is because the transition is not in any one statement; rather is found across a trajectory of statements made over time. A clue to addressing our challenge, and building our framework of difference can be found in structuralist linguistics, drawing primarily from an understanding of paradigmatic and syntagmatic structures within language systems. A structuralist approach to language is most often associated with the discipline of semiotics, a full discussion being beyond the scope of the dissertation at this time. For a useful primer to the subject, including detailed descriptions of paradigmatic and syntagmatic structures, I refer the reader to more authoritative sources (Sebeok, 2001, Webb, 2003, Chandler, 2007, Kress, 2010, Hébert and Tabler, 2020).
As a relevant example, consider a small segment of transcript from the Grasshopper Skateboards presented earlier in the chapter. At L15, student BL introduces an object, which he refers to as a “skateboard”. At L16, the tutor seeks to clarify this introduction by asking whether what is presented are “the materials for…your skateboard?” In our common sense coding scheme, a link was made between the two statements by virtue of the presence of the term “skateboard”. Though there is arguably a connection between these two statements at the level of conversational topic, based on the presence of a common word. However, linking by similarity leading to frequency of occurrence may not be useful when discussing narrative transitions. Rather, the addition of a particular word (“your”) identifies at least two Understandings of skateboards in the design space — the generic skateboard that is under examination and analysis, and the prototype that is being designed as part of the student project. These two different skateboards align to the existing narrative and the preferred narrative respectively, demonstrating the premise of a decomposed project, drafted at the conclusion of Chapter 4 and sketched in Figure 19.

This simple example referencing a skateboard in the transcript from the project Grasshopper Skateboards highlights distinct structures within the discursive exchange which may be impacting our ability to understand narrative transitions within the projects as they unfold. First, syntagmatic structures involve relationships of words within the sentence structure itself. Syntagmatic constructions are evident in the surface level of sentences and utterances, where meaning is afforded through the order and position of the words with respect to the grammar employed (here being the English language grammar). Second, and by contrast, paradigmatic structures involve potential word choice within a sentence from the wider lexicon available. Paradigmatic construction involves the possibilities of other words outside the provided word within the sentence which might have been employed in describing an event, thereby directing the focus of the audience to some different understanding of an event. An illustration of these
two structural perspectives using the utterance at L15/16 from our transcript is found below in Figure 27.

**L15:** *This is skateboard.*

**L16:** *This is decking for ... from*

![Diagram showing paradigmatic and syntagmatic structures](image)

*Figure 27: Illustration of paradigmatic and syntagmatic structures operating at sentence level*

Here, our challenge to understanding reflecting on difference, enabling the narrative transitions within the project, becomes a bit clearer. With node-link analysis, relationships between sentences are made using what is common, within sentence sets, based on similarity and frequency of occurrence. However, understanding the transitional shifts at sentence level requires an utterance, as well as a response to the utterance. The example provided in the segment of discourse above highlights a paradigmatic transition, with the addition of an identifier in relation to the skateboard, moving it from “a skateboard” towards “your skateboard”. Though our example highlights a transition across sentences, and between speakers, in a paradigmatic shift, syntagmatic shifts are equally plausible. However, such transitional shifts will be difficult to find within individual sentences, or by linking similar constituent parts across them, without some way of considering the contrasting responses, to see how the transition is unfolding. Rather than attempting to identify what is similar across utterances, in a pursuit to understand narrative transitions, we argue that we need to find these transitions themselves, and this concerns difference and the moves being made to either expose it, or cover it up.

5.3.3 **Constructing a framework: part 1**
In understanding narrative transitions, we have deployed a common sense coding scheme based on an in vivo approach to coding transcripts from the product design project tutorials, linking commonly found words repeated throughout the transcript. However, the approach falls short with the assumption that words are making reference to stable and consistent types of things or actions. Initial steps towards a framework of difference will need to take into account not only types of things being discussed, but the relationships between those things under discussion.

In developing support for design educators in fostering design reflection, situated on narrative transitions, driven by difference, a supporting framework is useful to consider. Here in Chapter 5, in examining narratives in transition within design projects, through design education, we employed an approach to the social practice of design using tools which have been developed for understanding approaches to design cognition, developed mainly using protocols of individual designers at work, or teams of designers assumed to be operating as “teams of one” in coordinated, collaborative tasks (Goldschmidt, 1995). The chapter has thus far shown that an inductive approach to coding these interactions with these tools falls short since a tutorial conversation is predicated on turn-taking, and responses need to be regarded in partnership with utterances being made. The inductive scheme as employed, based on linking constituent parts in the narrative event frame composed of subjects, objects and actions, fosters an approach to text where relationships are based on similarity and frequency of occurrence. What has been revealed in a turn-taking, conversational approach in our tutorial episodes involves relationships between words, either syntagmatically or paradigmatically, and across speakers, using commutative practices to understand the emergence of difference.

Within our approach, the presence or absence of particular words, or the relationships between words in the utterance, alters the focus in the design space, and this is revealed in the turn-taking perspective of conversational structures. Our example in the previous section highlights that the inclusion, or exclusion of different words, or even the order of words, revealed in the
turn-taking episodes, has implications on what is understood in the design tutorial, and impacting the design space.

At this juncture, we adopt the perspective that tutorials are a particular type of interaction in the educational context where events shaping a student’s learning are discussed through conversation. A tutorial within the product design studio involves a variety of participants, including the drawings, objects, and structures under development within the design project. The development of the prototype between tutorial sessions positions it as a boundary object (Star et al., 1989, Star and Griesemer, 1989), and also as an intermediary device (Vinck, 2012, Vinck and Jeantet, 1995). In this capacity, the prototypes are objects under examination, but also subjects involved in outlining the events as they “talk back” (Schön, 1992b, Goldschmidt, 2003) to the participants in the tutorial. The prototype operates both as participant in the designer’s event space, being acted upon, as well as a text where the experiences and events are being read, and transcribed.

The accounts of the students in the tutorial discussion are supported by the presentation of these prototypical devices, understood as objects within the event, as part of the designers narrative of experience (Labov, 1972), regarding their work undertaken to transition the associated narrative within the project itself. Decomposition of structures into constituent components, followed by commutative practices on those constituents were outlined as being employed to move the narrative in transition.

The presence of artefacts in the product design space provides some specificity and reference to processes of design taking place prior to the tutorial session, and allows for consideration for what activities might need to be addressed in future. These prototypes, when understood as materials in conversation with the designer (Schön, 1992b) might also be considered as participants in the generation of the design narrative transition, which are effectively being read
by those other participants they are engaged with, where changes to the prototype, through commutative practices, enable it to be read in new ways, since difference comes to the fore. With difference understood as the driver of texts, extending this perspective of text to the physical artifacts being discussed, scrutinised and explored in the design project tutorials (including drawings, models, prototypes, exemplars, etc) resonates with our initially identified themes of projects, narratives, and reflecting on difference, if difference is what brings text into being (Kress, 1992, Kress, 1989a). In this view, the prototype operates both as participant in the designers event space, being modified, as well as a text where the experiences and events are being shared, critiqued and reflected upon.

As part of our framework, we can begin to see that in employing a narrative approach to product design practice, 4 types of semiotic moves are able to make difference apparent through semiotic moves associated with syntagmatic and paradigmatic structures in language. These moves correspond to the types of actions (and their implications) that the student designer outlines being engaged in during their product design projects. Looking beyond the 5 constituent components in our event structures at the utterance level, other words are sometimes added, sometimes subtracted, from the exchanges between the tutor and the student. In our example regarding the skateboard, a particular move involving substitution, a form of double move involving subtracting something, whilst adding something else, is evident in the substitution of “a” for “your” in reference to “skateboard”. One final semiotic move which is also possible is permutation, where the substitution move involves changes in the syntagmatic order of the utterance. These 4 basic moves, evident in turn-taking speech activities taking place in the design tutorials, are in reference to the experiences of the students as they’ve engaged their product design projects, in narrative form.
5.3.4 Next Steps

The overarching thesis examination, the key question presented in Chapter 2, involved the ways in which student reflection was fostered, in the project-based learning approach to design practices, where the aim of the project is to transition from an existing narrative about a problem state, to an alternative narrative which addresses the problem space. It was outlined in Chapter 2 that reflective activity is considered a key attribute of design thinking and process activity (Schön, 1983, Cross, 2011). Stepping back from our own research practice, and analysing our "common sense" approach to coding the tutorial transcripts (Goldschmidt, 2014) resulted in highlighting variation within the 5 key constituent components of the events unfolding in the past and anticipated for the future, but did less to help our understanding of reflective activity about the narrative development within the project, situated around assorted readings of the objects under examination, as texts, situated in difference.
In Chapter 6 we introduce and apply an alternative approach to examining narratives in textual which is able to highlight the semiotic moves being employed more readily than the link-node analysis employed in Chapter 5. The examination of the tutorial transcripts using Quantitative Narrative Analysis (Franzosi, 2004, Franzosi, 2010) will help to advance efforts to concretise our framework of commutative moves within the design space, facilitating the design of narratives in transition, through reflecting on difference, during product design project development.
Chapter 6
Rewriting Narratives: Dimensions of Difference (2)

The most fundamental concept in cybernetics is that of "difference", either that two things are recognisably different or that one thing has changed with time.

(Ashby, 1956)
6.1 Introduction

The overarching thesis has been exploring project-based approaches to design practice, involving the transition from an existing narrative towards an alternative one. The ambition was to identify the difference between these two narratives, and how this difference was being reflected upon, enabling the project to continue to move towards its goal. Texts, of which narrative is one type, arise because of difference (Kress, 1989a, Kress, 1992, Kress, 2010). Reflective activity has been highlighted as a key attribute of design thinking and process activity (Schön, 1983, Cross, 2011). The quote that opens this chapter from Ashby highlights that systems and processing thinking as cybernetics, a field of study which has started to receive increased attention as a possible approach to dealing with complexity through design, is also primarily concerned with difference, lending some support to our investigations examining design projects, generating texts associated with some form of transition, requiring reflection on difference associated with these narratives of transition.

The case studies analysed in Chapter 4 provide a perspective of postgraduate product design students engaged in product design projects, which I described as involving narrative transitions, facilitated by the development of models and prototypes. Projects were presented over the course of an academic year, which were summarised in a student design book, which provides an account of the overall project as engaged by the student, introducing their analysis of the problem, and their developments of an appropriate product prototype as a potential solution. Each project was highlighted as involving a set of narratives, the existing narrative and the preferred narrative, which required some sets of design moves and development to be able to address the transition between the two.
Chapter 5 continued with practices of decomposition, but our attention shifted to examine moves associated with narrative transitions, and reflections on difference, from inside the project itself, at intermediary points during student-tutor tutorial sessions. These sessions were thought of as verbal protocols regarding experiences of product design practice, process and development. They were analysed using node-link graphing, a common approach to protocol analysis within design research (Chai and Xiao, 2012). To do this, utterances were decomposed into the constituent component parts, rather than parts-of-speech, using an in vivo coding approach based on common sense. Repeated occurrences of words across utterances (as nodes) provided the opportunity to link utterances together, to ascertain the ways in which transitions were taking place. This perspective was reflexively challenged, as it is often supported by employing a secondary coding scheme which requires categorising various utterance types, nominally representing distinct knowledge structures within the text (Suwa et al., 1998, Gero and Kannengiesser, 2007, Goldschmidt, 2014).

### 6.1.1 Lessons learned

What was missed in this second attempt at examining narrative transitions is the ability to expose the transitions themselves, which involve ascertaining the differences across the text, as opposed to connecting through similarity. A series of semiotic moves which are employed to uncover difference were outlined. In summary, Chapter 5 suggested that an alternative approach to examining the transcripts, which allows for making apparent the transitional moves, would be required, leading into approaches to be discussed here in Chapter 6.

The application of linkography as a technique in analysing the tutorial transcripts in Chapter 5 was based on a “common sense” approach (Goldschmidt, 2014) to decomposition of events into constituent components. When reflexively considering this application, little was revealed about narrative transitions, reflection, or difference, and may be in part due to a secondary
priori coding scheme to facilitate linkography was not defined. What was usefully uncovered were the various topic segments under discussion in the tutorial frames, and their relative importance to design project development based on repeated word occurrences, degree measure, modularity clustering and eigencentrality values generated from within Gephi. These measures from available off-the-shelf software, we argued, are commensurate with identification of “critical design moves” commonly discussed in linkography literature.

The problem, I argued, is that tutorials are unlike conventional protocols examined by other design researchers using linkography, or other graphing based approaches to the transcripts protocols. Rather than being a “think aloud” approach to problem-solving, tutorials are interactions where retrospective events shaping the design project are discussed, through turn-taking conversations amongst participants in the design space (Gibson, 2005, Hutchby and Wooffitt, 2008, Glock, 2009, Oak, 2011). The tutorials expand upon various experiences of the participants, and as such might be better understood as a form of narrative text themselves. Narratives were presented in Chapter 2 as sequences of events tied together, by a narrator, constructed for a particular purpose or disseminating a particular message, to an audience. Narratives, their structure, and decomposition of them into sequences of events, were discussed in Chapter 2, where scholars of narratology and narrative inquiry (Todorov and Weinstein, 1969, Labov, 1972, Greimas and Porter, 1977, Franzosi, 2010, Riessman, 2008) were introduced.

Recall Kress’ point from our Chapter 2 discussions of narratives, that difference is the driver of text generation (Kress, 1989b, Kress, 1989a). Texts come in a variety of formats, including narrative, conversation, lecture, or think-aloud protocols. Types of texts correspond to the context of the discourse and the nature of communicative exchange under way. Here, we have been extending this perspective of text to the experiences associated with the physical artifacts being presented, scrutinised and explored in the design project tutorials (including drawings,
models, prototypes, exemplars, etc) where these prototypical artefacts are understood as participants, as the objects within the narratives event structure. Through this position, our turn-taking conversations are not a homogenous text, but a series of inter-woven texts, responding to an unfolding narrative regarding the past and future experiences of the respective narrators, including the prototype. Each participant is creating their own text, driven by difference, from their own narrator position. Adopting this narrative perspective to design projects supports our initially established observation relating projects, texts and narratives, and reflecting on difference, but requires more than linking of the available words in the transcript. To understand the narrative transition, we move towards understanding the paradigmatic and syntagmatic moves which are taking place in turn-taking conversations amongst participants engaged in the tutorials.

As outlined at the conclusion of Chapter 5, one key finding from our approaches to text processing approaches associated with turn-taking conversations may need to consider the emergence of listener responses and their relationship to speaker utterances, in order to see and understand narrative transitions through semiotic commutative practices, leading to difference, and subsequent reflection. 4 types of basic semiotic moves were outlined as possible in semiotic commutative practices (Chandler, 2007, Hébert and Tabler, 2020). A potential method for identifying these moves in our tutorial texts was outlined in Quantitative Narrative Analysis (QNA), which can make use of the same data formats already constructed through our decomposition approaches in the previous chapter.

QNA is a distinct approach to examining how narratives are shaped, formed, and transitioned, and was developed in work of Robert Franzosi (Franzosi, 2004, Franzosi, 2010). Franzosi’s approach to understanding narratives provides a different perspective from the tools discussed and applied in Chapters 5 and 6. Namely, QNA is an adaptation of a Term Rewrite System (TRS) predicated on a story grammar approach to text. The methodology provides an
opportunity to see how the 4 semiotic moves described at the conclusion of Chapter 5 (addition, subtraction, substitution, transposition), which are referred to as “production rules” in rewriting logic terminology (Baader and Nipkow, 1998, Meseguer, 2012). Production rules work in the understanding that a unit of analysis is often composed of a set of smaller ones, which can stand in for the larger unit and facilitate alternative operations previously not available. This perspective provides an opportunity to understand transitions within the events, through seeing these production rules in operation across the utterances by the speaker and the associated replies from the listener. From a design perspective, accounts within the text are situated around objects under development (prototypes) and the associated actions in transitioning the project narratives through the transitions of the objects which form part of that narrative.

To understand students’ reflecting on difference, and its relationship to narratives in transition within design projects, it is proposed that a secondary examination of the narrative events might be useful in Chapter 6, but this time adopting a QNA perspective as our tool for interrogation, using production rules and story grammars in examining student design projects, to uncover the processes associated with narrative transitions inside the project, in more detail.

6.1.2 Moving forward

Here in Chapter 6, we move the thesis forward by outlining how QNA was applied to our design tutorial interactions. First, I provide a brief introduction to QNA and story grammars (Franzosi, 2004, Franzosi, 2010) and rationalise extending our examination of the tutorials using this methodological toolkit with the same datasets from the three student projects which informed our analytical study from earlier chapters. Second, I’ll extract detailed examples from transcripted exchanges in the tutorials to provide some concrete examples of the production rules applied to the narrative events under discussion across the respective utterances, moving us beyond the single utterance as a site of the event. The network graphing
measures derived from Gephi, namely degree, modularity and eigenvalue centrality, will help to organise transcribed text around topic segments, revealing critical moves (Goldschmidt, 2014, Hatcher et al., 2018) being made. Lastly, I provide a summary discussion of the work done in the chapter, examining how difference is being managed at the event level, through the application of production rules by different participants in the tutorial frame. Limitations are outlined, namely that narrative events are often about “the action” (Labov, 1972, Franzosi, 2010, Halliday and Matthiessen, 2014), but the tutorials seem to focus on discussions involving characterisations of things.

The chapter concludes through advancing our theoretical framework discussing the production rules associated with narrative transitions and reflections on difference in generated texts, and recognises that challenges to the framework remain, and prepares the groundwork for a further examination of narrative transitions, with an emphasis on the multitude of narrators providing different “narratives of experience” (Labov, 1972) within the tutorial context.

6.2 Quantitative Narrative Analysis (QNA)

Quantitative Narrative Analysis (QNA) is a method of decomposing clauses inside of texts into constituent parts to examine the dynamic character of narratives, particularly across space, time and narrator. QNA differs from the previous efforts at decomposition employed in Chapter 5 in that it employs a story grammar consisting of subjects, actions and objects, rather than parts of speech involving nouns and verbs. The problems of our common sense approach to coding with parts of speech was discussed in greater detail at the conclusion of Chapter 5. Here in Chapter 6, we approach decomposition of narrative into events, and further decomposed into subject, action, object, time and place through the application of QNA’s rudimentary story grammar.
Our earlier approaches understood texts as protocols, and these were decomposed into their constituent parts-of-speech (Dong, 2009b, Ullmann, 2015), and linked common and similar words occurring across sentences in the transcripts texts of tutorials. Rather than linking words based on similarity and parts of speech, QNA implies that an established set of production rules, associated with a story grammar (Franzosi, 2004), are at the foundation of all narrative texts. However, a story grammar is generic and in actual language use is not strictly followed. Being able to identify changes taking place inside the story grammar as narratives progress, through watching the variability of use of particular constituent parts shaping events allows for understanding narrative transitions through collections of stories and accounts regarding a circumstance. Recall my clarification between story and narrative in the literature review from Chapter 2, where a story is the recounting of a circumstance through the sequence of events involving actors engaged in action in some place and time, whilst the narrative, despite being constitutently similar, involves the perspective of the narrator in outlining which events within a circumstance are relevant and important, thereby framing a story in a particular way.

QNA takes advantage of syntagmatic structures of language, where sentences and utterances are often understood to be in the form of the rudimentary configuration of an event. However, QNA does more than just decompose narratives into events, and events into highlighted structural parts. It is an approach to understanding the dynamics of narratives and examines how they transition, comparing various accounts and stories describing similar sets of circumstances. The transitions in narrative are identifiable when understanding that a story grammar, as an abstract structural framework, is generally consistent across stories, but each specific story about a common circumstance employing a common grammar may differ slightly, depending upon the syntagmatic ordering or paradigmatic choices made by the narrator, in the depiction of events and sequences.
To do this, QNA begins with a system of notation, over a system of codification as commonly employed in content or protocol analysis. QNA employs an approach to stories and grammars which relies on the coding system naturally found in human language, employed naturally by generators of text, whether it be writers or speakers. Franzosi describes it this way:

**Coding, in content analysis, assigns text to aggregated categories, typically theoretically defined. Data coding and data aggregation go hand in hand, the coder performing both tasks. In a story grammar approach to coding, coding consists of assigning parts of text to the natural and familiar categories of a story: who was involved, what they did, when, and where. Coders are not involved in theoretical decisions during the coding process …**

... however much researchers may try to reduce coders’ discretion in fitting text into abstract categories through written coding rules, the abstract coding categories invariably result in the contamination of the measurement instrument (Franzosi, 2010)

QNA is a particular example of a Term Rewrite System (TRS), seen as a formal approach to decomposition of sentences and utterances, which might better accommodate our examination of narrative transitions, whilst salvaging our work from the earlier approach to in vivo “common sense” coding employed with linkography in Chapter 5. Specifically, Franzosi’s QNA and its application to narrative texts is suggested as potentially providing new insights into the narrative transitions unfolding in the student design project, by understanding the tutorials as narratives, rather than protocols. It is suggested here as being an alternative formal perspective to exploring the narrative transitions in the design tutorial transcripts, since it involves an analysis of components within the narrative event depictions themselves, examining the ways narratives transition and change, dependent upon the syntactical structures of narrative event clauses, as well as the composition of sequences of events into narrative texts themselves.
6.3 Term Rewriting

At the end of Chapter 4, in our analysis of student case studies highlighting that projects might be understood as narrative transitions, I presented an approach to deconstructing the project, through actions of decomposition, seeing the design projects as an activity to transition the narrative events through a series of semiotic moves associated with the constituent parts of the event. In Chapter 5, these components of the event clause, namely subjects, objects actions, within a time and place, were the foundation of the “common sense” coding scheme use to generate our linkographs and network graphs. A particularly subtle difference in approaches between our previous common sense coding and QNA is the recognition that an identified word in a text, such as “skateboard” can operate either as a subject or object in an event clause, highlighting narrative focus, but also whether the term is acting, or being acted upon, depending upon narrator focus and the terms allocation as either subject, or object.

The practice of decomposition and its resultant outcomes is formally understood as a Term Rewrite System (TRS) (Baader and Nipkow, 1998). It involves some entity being replaced through a set of production rules (Martí-Oliet and Meseguer, 1996, Viry, 2002, Meseguer, 2012) by a series of smaller entities, implying that one side of the equation, when acted upon by the production rule, can be represented by the other side of the equation. The production rule is indicated in Figure 19 as the arrow which moves us from left to right in each of the equations. TRS is also employed by Chomsky (1957) in his analysis of syntactical structures, rewriting sentences into smaller constituent phrase components, and then rewriting further into parts of speech, illustrated in Figure 26. In Natural Language Processing, using Chomsky’s method, the system is evident in applications which examine grammatical structures, where the TRS syntax, for example, is explicitly used in the python programming language. From a design perspective, the earliest attempts of using TRS might be found with Christopher Alexander’s work (1973), whereby he describes complexity in design using a tree structure to
deconstruct a kettle into 21 specific requirements. The diagramme is recreated below in Figure 29.

Figure 29: Alexander’s (1973) term rewriting application to outline complexity of design, reducing a kettle into 21 requirements

An example of the system implemented may help our purposes in explaining this TRS notation system and how it is used. The example draws from the tutorial transcript presented in Chapter 5 from Grasshopper Skateboard (see Figure 22 for the excerpt), using L21 as our example:

“That is one I made myself.”

The sentence is constructively ambiguous as it places the skateboard being referenced (That) as the subject of the statement. The presence of two verbs (is, made) highlights the statements’
complexity since the verb is sets us up for a descriptive account, an ontological categorisation. The sentence can be simplified and might be understood in an event framing as:

“**I made that one**”

In this rearrangement, an event becomes clearer, with the subject (“I”), engaged in a particular action (“made”) towards an object (“that skateboard”). The notation system Franzosi employs embraces this framing of the event as a tuple (Franzosi, 2010), a data structure which contains multiple parts. Using the notation, this sentence might be understood as a specific example of the following rewrite rule, outlined below in Figure 30.

```
  event       →  [<subject><action>[<object>][<time>][<place>]]

  BL L21     →  "I", "made", "that one"
```

**Figure 30: Decomposition of the narrative event**

The notation system employs conventional regular expressions (or regex, for a useful primer see (Goyvaerts and Levithan, 2012), and is generally used as a method for advanced pattern searching through complex search terminologies, allowing for terms to be required, optional, multiple, Boolean, generic or specific instances.

Though there are visual similarities evident, this annotation should not be confused with to constructs of predicate logic, since design and logic, as March warns us, are not interested in the same thing:

> *Logic has interests in abstract forms. Science investigates extant forms. Design initiates novel forms. A scientific hypothesis is not the same thing as a design hypothesis. A logical proposition is not to be mistaken for a design proposal* (March, 1976).
March’s warning, made in 1976, is certainly worth heeding, particularly if the emphasis is based on forms of predicate logic which require determination about the truth validity regarding underlying propositions. However, rewriting logic differs from predicate logic in that it is simultaneously a logic and a semantic framework (Martí-Oliet and Meseguer, 1996, Meseguer, 2012), affording us greater flexibility, particularly when employing practices of decomposition in a common sense way, related to everyday practices such as transformational grammars (Chomsky, 1957).

To move between general relationships and specific instances, a rewrite system employs a specific set of notations in highlighting how to move from the general to the specific. The system of notation has some strong commonalities with the systems of regular expressions employed within various forms of logic and many computational processing applications. The notation system employed by Franzosi involves a selection of the total available TRS symbols (Dershowitz and Jouannaud, 1990). These are outlined in Table 16 below.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>Angle braces contain a narrative element, which can be further decomposed (rewritten) into additional constituents</td>
</tr>
<tr>
<td>{</td>
<td>Curly braces contain a narrative element which can occur repeatedly</td>
</tr>
<tr>
<td>[</td>
<td>Square braces contain a narrative element which is optional, or implied.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>denotes the decomposition of an element into constituent components</td>
</tr>
</tbody>
</table>

Table 16: An outline of Franzosi’s Term Rewrite System (TRS) notation nomenclature as employed in Quantitative Narrative Analysis (QNA).

Franzosi’s QNA makes use of a system of notation developed by Van Dijk (1972), and these were outlined in Table 16. QNA’s notation system shares common syntactical features with other notation systems, including set theory and algebra in mathematics, regular expressions used in computational search functions, and also with formal rewriting logic syntax. However,
though common symbols are employed, their meaning differs across these domains and that makes things confusing. To simplify our framework, relevant to representing narrative transitions in a product design context, some features of the formal QNA story grammar notation are not used here, in lieu of a simpler set theory approach, for illustrative purposes, in outlining the decomposition involves reduction to a collective set of constituent components, and constitutes the most basic of grammar formats, if considered a grammar at all.

For Franzosi, the use of notations in this way seems more heuristic than actual machine-search oriented. QNA employs a manual process of filtering through text, recognizing this basic event structure and compiling data entries from each event found within his stories under examination, matching this ‘story grammar’ (Franzosi, 2010). Each story from which events are extracted is outlined as a case. For Franzosi, each case story is a newspaper article based on a particular reporting related to his research area of interest, Italian Fascism. Franzosi suggests the narrative flows from the case story in the choices of specific instances about a particular set of events, following the understanding of the difference with others (Halliday, 1961, Propp and Wagner, 1968, Todorov and Weinstein, 1969, Labov, 1972). What is important is the observation of changes over time, highlighting that the narrative (the selection or description of events and their components) has changed, somehow — allowing for analysis of this change in narrative based on the factors associated with the cases in which stories are being told. For our purposes, what QNA brings that is critical for this thesis is an opportunity to see the textual changes taking place across the project and a set of tutorials, over time, and more locally, within the tutorial conversations, between the tutor and student, in a situated context.

6.4 Revisiting protocols: Grasshopper Skateboards
Moving away from the approach in Chapter 5, where similar things were linked together, we revisit the tutorial transcripts from the three case studies already explored to apply an analytical approach structured on QNA, examining how the conversations between the tutor and the student at these intermediary events in the project help move it forward, looking for the mechanism of transitions within the narrative event clauses in the tutorials.

The narrative event is straightforward to identify in the form of a clause uttered by a speaker, and our intuitive coding exercise from Chapter 5 can be of assistance since it made use of linking the various constituent elements across the corpus to which the speakers are repeatedly referring, despite challenges to examining the protocols in Chapter 5 described as stemming from an “inter-textual” rather than “intra-textual” perspective of the interaction.

Linkographic techniques are able to provide evidence about design moves, through forelinks, and backlinks (Goldschmidt, 1990, Kan and Gero, 2008, Goldschmidt, 2014), commonly referred to as out-degree and in-degree in graph theory parlance, as described in our analysis and discussion at the conclusion of Chapter 5. Though other network tools, such as Gephi, further algorithmic functions become available to provide us with additional metrics from the same dataset, which can now help focus our examinations into events, particularly through isolating the transcripts into the various "connected communities" or topics within the tutorial transcript, seen through modularity clustering (Newman, 2006, Blondel et al., 2008), and prioritising these clusters by degree of importance through identifying which cluster contains the most significant utterances made (eigencentrality value). These two measures allow us to readily identify the “critical moves” from linkography, with relative certainty.

To facilitate an examination of rewriting practices possibly taking place through the lens of QNA, natural language processing techniques were applied to extract the various parts of speech (PoS) and isolate them into the respective categories of nouns and verbs, adjectives and
adverbs as well as the grammar components including terms involving modality (i.e. would, could, should) and conjunctions (i.e. and, but, or). Each utterance made by the respective speaker in the transcript was processed in this way, providing a set of dataframes maintaining connections to communities (modularity) and relative importance (eigenvalue) along with parts of speech employed. Each modularity cluster was thematised according to the statement which presents the highest eigenvalue within the cluster, understanding that these statements are the central statement associated with clustered topic. An index is provided numbering each utterance to ensure the temporal ordering of narrative event clauses is maintained.

Utterances in the topics flow sequentially but not always found consecutively within the transcript proper. This is because topic segments are interwoven and inter-related with each other. To facilitate our analysis of the transcripts using QNA, topic clusters are discussed and presented in segments within the topic, relating to their sequential appearance in consecutive running order. In short, chunks of exchanges are presented together where the flow of conversation needs maintaining, and stitched together over consecutive chunks to re-create the full topic as it is engaged across the transcript. Where necessary, related topics are introduced, referenced and discussed.

6.4.1 Grasshopper Skateboards - Session 1

The Grasshopper Skateboard project was introduced in Chapter 4, and content analysis of course work information outline a project involving a narrative transition whereby a skateboard was designed which is more sustainable and environmentally friendly than existing models. Existing skateboards relied heavily on Canadian maple as the material of composition, whereas a new design involved substituting maple for bamboo, whilst substituting for other environmentally friendly components. The design prototype aimed to provide a comparable performance, but improved environmental impacts at the products end-of-life. As discussed
earlier in Chapter 4, Table 9 presents an overview of the local processes uncovered in the Grasshopper Skateboards project, through the modularity and eigenvalue measures generated in the analysis of the transcript data from the first tutorial session.

Table 9 identifies 12 modularity clusters in the first tutorial interaction, consisting of a series of events which are situated around actions and objects, and their attributes, which comprise the event structure. The central process in the network is thematised as composition, where the making of the prototypes comes under scrutiny. Experiment is the second prominent process, in which actions from past prototypical production is scrutinised. Materials Preparation and Materials Dimensioning are the third and fourth topics outlined, listed as near equivalent importance with respect to similar eigenvalues returned in their main topic utterance. These topics highlight future actions necessary to be taken in order for further composition and experimentation to progress. These four prominent topic clusters are now more closely inspected through the lens of narrative events, based on QNA rewriting principles, as part of the project’s emphasis on narrative transition.

Composition is the first topic under examination. At line 17 of the transcript, the most significant statement, presenting an eigenvalue of 1, is uttered by BL, the student:

"That’s for like what the proper make-up of the skateboard is ...".

From this statement, it is inferred that the topic being discussed is regarding "…the proper makeup", or the composition of the prototype. BL has entered the tutorial space with a set of objects. Some of these objects are predecessor artifacts (Morch, 2013), being exemplars of skateboard deck construction from other manufacturers. Some of the objects under examination in the tutorial space are materials experiments that BL has constructed in the workshop as part of the development of his sustainable skateboard project.

Below is the first chunk of the topic segment, consisting of 15 lines of talk.
This sequence starts with an introduction to two artefacts to the tutorial: a predecessor artefact which is assisting the student in understanding the conventional composition of a skateboard decking (L17: "... the proper make-up...") followed by an experimental version that BL has constructed himself in the workshop (L21: "...I made myself"). These deictic references ("This is...", "That's one...") are an indication that the student is making a distinction between these two artefacts on the basis of the level of personal involvement associated with construction. These skateboard decks, as objects of the narrative under consideration, are differentiated, in one respect, on the basis of their materiality, the predecessor artifact being constructed of maple, whilst the experimental one containing samples of bamboo.

This sequence of statements primarily employs the verb phrasing "...is a...", which we refer to here as an isa clause. Such clauses are distinct from our understanding of event clauses in that nothing appears to be happening. Rather, the isa clause is form of reference to external aspects of the world, establishing identity, relations or possession. Such clauses, as discussed in Chapter 2 were understood by Halliday as distinct from actions which recount experiences of external or internal event happenings (Halliday and Matthiessen, 2014). The isa clauses are
indicative of orientations in Labov’s (1972) framing of stages of narrative. These orientation clauses provide a backdrop which contextualises the complicating action, one of the event clauses in Labov’s grammar of narrative experience corresponding to the particular event moment where something of significance has occurred.

Despite our earlier insistence that narrative event clauses are easy to locate and identify, the transcript is based on spoken conversational text, and appears messy, piecemeal, and full of other utterances conversation markers (L18: “Okay”), which are important in conversational exchange but don’t seem to fit within the narrative event framework we outlined as part of QNA — namely, it doesn’t come in a neat format like written, edited text might, as found in the student design book. Difference between forms of text (transcripts vs protocols) has already been discussed in the earlier chapter as a limitation of employing linkography on transcripted, conversational structures. Franzosi outlines these challenges also exist within written text, and outlines that part of the requirements of re-writing involves cleaning up data. He states:

…it is important to note that the process of narrative coding has involved some manipulation of the original text, however minimal: forming sentences out of clauses, dropping descriptive clauses from the coding, and incorporating important elements of these clauses into the <circumstances> of coded narrative clauses, notably <space>, and even rewording the language of some clauses... (Franzosi, 2010)

In contrast to the predominance of “…isa…” clauses, BL makes his first action-oriented utterance at L21, indicating that one of the decks under discussion is one that he made himself, presumably in the studio or the workshop. The transcribed utterance (“That’s one I made myself”) is re-presented below, in line with Franzosi’s recommendations just quoted, in order to accommodate our examination using his story grammar approach to the narrative event clause, highlighting more clearly the object, the action and the subject in the utterance. The
event grammar, and the re-written sentence, have already been presented as an exemplar of our approach to QNA, illustrated in Figure 30.

The tutor follows this statement with a set of questions, asking whether this particular board is made from bamboo (L22), with BL clarifying that it is composed from a combination of materials at L23:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>BL</td>
<td>Bamboo and with maple.</td>
</tr>
</tbody>
</table>

At L27, BL makes another *isa* statement, suggestive of another orientation clause. He presents an attribute of this new constructed board, namely that of strength, which he qualifies, suggesting the bamboo construction is "…very strong." Here, an ontological difference emerges, a referential one of degree, through a comparison of the attributes of the new board with that of the existing one on the level of performance. As outlined in the case study description from Chapter 4, the main aim of the Grasshopper Skateboard project is to make a sustainable skateboard using new material compositions, but without compromising the overall performance. His initial perplexity regarding the appropriate composition of the board using alternative materials seems to have made positive progress. The tutor responds with a question, seemingly surprised, but generally positive.

In all, this first sequence of utterances consists of 14 lines of conversation, with a balanced number of utterances seemingly made by both tutor and student. In isolating the parts of speech, a total 14 verbs were employed, 9 of which were “is” and one being “am”, all verb types understood as verbs articulating a “state of being”, one of the three main types of verbs within the narrative frame outlined by Halliday (1961, 2014). Of the remaining 4 verbs, two are gerunds, one of which (L16: “decking”) is structurally ambiguous, since it may also be a reference to a component of the skateboard (the decking) itself.
There are 16 nouns present across these 14 lines, with multiple references made to “skateboard” (3); “bamboo” (3); materials (2), and; maple (1). This is to be expected since the introduction of the prototype into the tutorial, the narrative object being designed, is under discussion.

Two adjectives are employed in this small sequence, both by the student (L17: “…proper…” L27: “…strong…”).

Though this “bag of words” approach to analysis of this first segment, we are able to see clearly words being exchanged, repeatedly, highlighting the linkages made in the original construction of the linkograph datasets through our inductive coding practice. However, how does this help us with our QNA approach to analysing transitions, through difference? Simply put, the coding scheme adopted connected the core components of the narratives looking for similar instances of words uttered, but a number of words here don’t necessarily fit inside that core structure. Notably, descriptive terms such as adjectives and adverbs are nominally linked, particularly when descriptions infer object attributes, what Deleuze referred to as ‘determinates’, discussed earlier in the literature review in the section regarding difference (Deleuze, 2014). Recall that determinates were things in the world, objects and their properties, and these were held in relation to determinables, the concepts, categories and classes of things and their associated attributes.

In contrast to other studies examining designers and their employment of particular parts of speech, notably nouns (Mabogunje and Leifer, 1997, Stacey et al., 2009), our preliminary analysis of this small sequence of does not seem to highlight a correspondence between creativity and the number of nouns used within the tutorial. Rather, I suggest that we see repetition of nouns as a result of various references to determinates (Deleuze, 2014), things physically present in the design space. These repeated references highlight difference where we are distinguishing between determinates under examination at different stages of
progression in the project. More specifically, let’s reconsider L15-17, examining this exchange through a story grammar approach adopted from QNA. These three lines are illustrated below in Table 17.

<table>
<thead>
<tr>
<th>Event</th>
<th>Subject</th>
<th>Action</th>
<th>Adjective</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>L15</td>
<td>This</td>
<td>is</td>
<td></td>
<td>[the] skateboard</td>
</tr>
<tr>
<td>L16</td>
<td>This</td>
<td>is</td>
<td></td>
<td>[the] decking...</td>
</tr>
<tr>
<td></td>
<td>This</td>
<td>is</td>
<td>the material</td>
<td>for your skateboard</td>
</tr>
<tr>
<td>L17</td>
<td>That</td>
<td>is [for like] proper</td>
<td>the makeup</td>
<td>of the skateboard</td>
</tr>
</tbody>
</table>

Table 17: Corresponding story grammar with excerpt L15:17 from Grasshopper Skateboards (Session 1).

In this format, we can see more clearly the narrative clauses and the story grammar unfolding across utterances. However, what this also clearly reveals is the lack of “doing” verbs (Halliday, 1961, Halliday and Matthiessen, 2014), highlighting that currently this segment itself does not comply with an anticipated narrative event clause outlined by Franzosi’s story grammar approach within QNA. In that framework we see people (subjects) doing things (action), as opposed to what is present here, a student and a tutor describing things. The presence of the adjective “proper” at L17, however, suggests a paradigmatic insertion, a commutative move by addition, discussed in the previous chapter (Chandler, 2007) which brings about difference, highlighted through identification of the exemplar skateboard deck and its congruence with the determinable concept which defines the object in the design space. This is one of the 4 principles of reason, outlined by Deleuze in the literature review. In the same segment, only moments later at L21, a paradigmatic move by substation, when the student introduces a second skateboard deck, identified as “one I made myself”. Here, difference now emerges through opposition, another of the Deleuzian principles of reason that addresses difference, whereby we have two determinates in the design space, understood as two examples of a determinable concept (skateboard), possessing similar attributes, but as determinates they are opposed because of the property of one being “made myself” by the student. The segment
moves forward with the tutor seeking clarification through a question (surprise?) seeking congruence between the determinates in the room, and their relationship to the expanded determinable concept, involving sustainability and the materials application of bamboo, in lieu of maple, bringing us back to the original project scope itself, with the transitioning between to narratives and the implementation of a narrative change, highlighted in Chapter 4 and illustrated in Figure 19.

L27 provides a further property description of the determinate skateboard, with the student declaring his views about another of the board properties under examination, this time strength:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>BL</td>
<td>I think bamboo is stronger.</td>
</tr>
</tbody>
</table>

This utterance provides a summary of events in the process engaged by BL, and leads to our first instance of the third verb type, thinking or feeling, as outlined by Halliday (Halliday, 1961, Halliday and Matthiessen, 2014). This clause, does three things:

- it provides an evaluation by the student about the determinate object in the form of opinion ("I think...") regarding aspects of the performance of his newly constructed board.
- He presents a second aspect of oppositional difference between determinates, regarding the material transformation associated with the predecessor object and his new construction, which he believes is stronger.
- He brings about difference in identification again, employing the word "bamboo" as a label for the particular outcome of his new board, which is composed of the material. "Bamboo" here refers to the deck constructed from bamboo and maple, to distinguish it from the “proper” board made exclusively from maple. This is understood since bamboo, as a determinate material does not possess the property of strength to a higher degree than maple. This local labelling, which conceptually binds an object to the materials of its construction, presents a degree of ambiguity in coding practices, if based on an understanding that elements of language are universally fixed, as opposed to locally constructed.
The evaluative event clause at L33 presents with the insight into reflective activity by the student in the examination of his design project work so far. To this point, reflecting on difference has emerged through a set of comparisons between two artefacts, based on a set of criteria that are concerned with particular attributes of the respective boards.

Up to this point, the tutorial conversation has primarily consisted of *isa* orientating clauses, with only two clauses clearly fulfilling our story grammar criteria of narrative events whereby a subject is engaged in action, most often with via objects. This orientation phase, it is suggested, is necessary on the part of the student to ensure the tutor is aware of the previous weeks’ activities between tutorial sessions. As outlined in Chapter 4, there are multiple timelines associated with the project, whereby the student is operating independently between tutorials as part of the project development, and the tutor’s timeline is structured into set contact points, as presented in Figure 11.

The next sequence of in this topic segment, however, sees a shift in the orientation take place as the tutor assumes control of the conversation.
As in the earlier segments, the first 4 utterances from the tutor are considered to be orientation clauses (Labov, 1972), highlighted by the ...isa... verb phrase being employed in the interrogation of the composite prototype present in the tutorial. The composition is detailed, outlining numbers of veneer layers present in the construction, and the alternating direction of each of the layers in composition. At L56, difference is manifest, in the semiotic addition of a negative to the ...isa... sequence, suggesting that the determinate object presented to the space for examination does not align to his understanding of the determinable concept, which he may be expecting. L54-56 is presented in story grammar format, below in Table 18.

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>TTR</td>
<td>This is a...this is seven layers.</td>
</tr>
<tr>
<td>50</td>
<td>TTR</td>
<td>So it is one, two, three, four, five, six, seven. So you got two outer layers planed down?</td>
</tr>
<tr>
<td>51</td>
<td>BL</td>
<td>Yeah.</td>
</tr>
<tr>
<td>52</td>
<td>TTR</td>
<td>And they are running concurrent?</td>
</tr>
<tr>
<td>53</td>
<td>BL</td>
<td>Yes.</td>
</tr>
<tr>
<td>54</td>
<td>TTR</td>
<td>And this is cross banding all the way through?</td>
</tr>
<tr>
<td>56</td>
<td>TTR</td>
<td>No, it is not.</td>
</tr>
<tr>
<td>57</td>
<td>BL</td>
<td>No, it is not. It is two layers and then the cross band. It is just the two-layer cross band.</td>
</tr>
<tr>
<td>58</td>
<td>TTR</td>
<td>That is bizarre.</td>
</tr>
<tr>
<td>59</td>
<td>BL</td>
<td>Yeah. That is what the way they do it on, oh no, that's not the normal deck. The normal deck is downstairs actually. But that is the way they do it on normal decks as well.</td>
</tr>
<tr>
<td>60</td>
<td>TTR</td>
<td>Really?</td>
</tr>
<tr>
<td>61</td>
<td>BL</td>
<td>Yeah. They have this layer and then the outer layer is called a face.</td>
</tr>
<tr>
<td>62</td>
<td>TTR</td>
<td>Uh-huh.</td>
</tr>
<tr>
<td>63</td>
<td>BL</td>
<td>Face veneer. And it is running the same direction as two layers and this underneath.</td>
</tr>
</tbody>
</table>

As in the earlier segments, the first 4 utterances from the tutor are considered to be orientation clauses (Labov, 1972), highlighted by the ...isa... verb phrase being employed in the interrogation of the composite prototype present in the tutorial. The composition is detailed, outlining numbers of veneer layers present in the construction, and the alternating direction of each of the layers in composition. At L56, difference is manifest, in the semiotic addition of a negative to the ...isa... sequence, suggesting that the determinate object presented to the space for examination does not align to his understanding of the determinable concept, which he may be expecting. L54-56 is presented in story grammar format, below in Table 18.

<table>
<thead>
<tr>
<th>Event</th>
<th>Subject</th>
<th>Action</th>
<th>Adverb</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>L54</td>
<td>This</td>
<td>is</td>
<td>cross-banding</td>
<td>all the way through?</td>
</tr>
<tr>
<td>L56</td>
<td>No</td>
<td>it</td>
<td>is</td>
<td>not</td>
</tr>
</tbody>
</table>

Table 18: Corresponding story grammar with excerpt L54:56 from Grasshopper Skateboards (Session 1)
A third dimension of difference emerges in this interaction, leading to reflective activity as part of the design project space under examination. Earlier in this segment, Deleuze’s principles of identification and opposition concerning two object determinates and their particular attributes was outlined, here, in this third segment, resemblance is the principle which uncovers difference, whereby the tutor does not perceive the resemblance between the determinate object, and his understanding of related determinable concept, situated in the properties of the skateboard decking composition and the process of plywood lamination, in which he has prior experience. The lack of resemblance, it would seem, is also present in the student, since it could be understood that the nature of the exchange at L59 is to confirm that the composition implemented by the student in the development of the new skateboard deck is, in fact, coherent with the approach adopted within the predecessor artifact. At L61, identification is again brought forth to manage difference in naming one approach towards lamination as involving a particular veneer type ("...the outer layer is called a face.") involving directly naming this attribute of the decking construction process.

The overall tutorial, from a temporal unfolding, begins to address a new topic from L64 onwards, involving discussions of a technical nature regarding how the bamboo needs to be prepared, in order for it to be laminated and the composition made ready to test for strength, another topic discussed throughout the transcript.

At L118, the student returns to the topic of composition, more specifically, asking a question of the tutor with regards to the technique of bent wood lamination.
Here, BL engages the tutor in personal experiences from the tutor’s past regarding technical processes he appears to be familiar with. The tutor explains his own perplexity (L56) at the presentation of the prototype, causing him to reflect and consider how the new skateboard deck has been constructed. The difference between the tutor’s expectation, and the reality of what is presented to him by the prototype is akin to Schön’s conception of "back-talk" (1983). This results in a doubt, uncertainty, ambiguity or surprise — something not anticipated. This is suggestive of another form of difference, in this case, a difference in a particular form of orientation between the tutor’s understanding from past experience, and what is presented in the current selection of artefacts.

This segment in the topic, however, also shows an emerging difference in roles, as the tutor moves away from being instructor, guide, or teacher, to something more personal, sharing...
experiences of process with BL in a more informal manner. As this topic segment opened with the student’s orientation of the previous week’s design project work in the tutorial space, the student assumed what we might understand as the role of narrator.

The concluding segment of this topic cluster, situated around a discussion involving material composition as part of the narrative transition in this project, involves three lines, its timing taking place at the end of the tutorial session:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>172</td>
<td>BL</td>
<td>I didn’t want to try it because I know it’s not going to hold the shape... [inaudible 00:10:07]. I could see...</td>
</tr>
<tr>
<td>173</td>
<td>BL</td>
<td>because from talking to MK and he’s been working with his bamboo what, since last year?</td>
</tr>
<tr>
<td>174</td>
<td>BL</td>
<td>And he said it’s like contact with moisture and they take the water like...</td>
</tr>
</tbody>
</table>

At L172, BL responds to a question from the tutor, who has asked a question which is aligned to another topic cluster, associated with materials preparation:

$L171$: *What happens when you don’t have the maple and it’s just straight bamboo?*

These three statements by the student, concluding this topic segment on composition, contains a complex set of clauses outlining events which did not happen, based on experiential accounts of a fellow student who worked with bamboo previously (*L173*: “from talking to MK...”). This final segment highlights another substitution in the evolving narrative of the skateboard development, this time involving the subject, whereby the experiences of others serve as an analogy to outline inaction on part of the student. Recall that analogy is our 4th principle of reason in managing difference (Deleuze, 2014), and is the first instance we’ve seen, through the employment of an alternative narrator position.

A full discussion of all topic clusters which have been isolated through our community clustering algorithm (Newman, 2006, Blondel et al., 2008) will certainly provide more richness
and details about the discussion associated with the project, it doesn’t necessarily provide us with more concrete details regarding the nature of transitions and difference involving material substitutions which are primarily taking place within this discussion between the student and the tutor. For instance, the topic cluster themed as “Experiment” presents a discussion of another material component substitution based on the opposition of hessian fibre in place of grip-tape (L132-L135); the topic themed as “Preparation” involves a discussion of the material attributes of bamboo (thickness, flexibility), in oppositional comparison to the same attributes of maple L41; L171); the topic themed as “Laminating” involves a discussion regarding the technical construction process, including mentioning the use of an eco-glue in lieu of conventional adhesives (L85), as well as discussions of special machines involved with preparing the bamboo to ensure the appropriate thickness (L71-74). In summary, as outlined, the tutorial is engaging a process where talk, conversation are employed to understand difference and narrative transition through moves being made by substitutions, leading to difference across determinates (objects and their properties) within known determinables (concepts and their attributes), returning to the discussion of principles of reason to managing difference, as discussed by Deleuze in Chapter 2 (Deleuze, 2014).

6.5 Analysis and Discussion

The Grasshopper Skateboards tutorial session presented here has been employed to highlight a particularly salient example of a product design project being decomposed into constituent parts, producing a sequence of events from the narrative; a series of events structured as subjects engaged in actions with objects in time and place; and a further production to extract the various objects from the event to discuss how and why modifications are being made, leading to new objects to be considered.
Our examination of the tutorial transcript was isolated to the prominent topic cluster, identified through the application of the Blondin algorithm within the node-link software package Gephi (Blondel et al., 2008, Bastian et al., 2009). The topics result from the linking exercise in Chapter 5, the results of which has been carried over to Chapter 6 to facilitate our ability to examine textual transitions, when subjecting the topic clusters in the text to an adapted approach to QNA (Franzosi, 2004, Franzosi, 2010), which was outlined as being better suited to identifying narrative transitions through semiotic moves at the event level than conventional approaches to node-link analysis.

6.5.1 Prototyping as Material Rewriting

Despite the QNA being expressly understood as a quantitative application able to identify and analysis narrative transitions over a large volume of text, our application of the method is not quantitative in the least, aiming to understand particular instances of transitions inside particular discursive exchanges towards building a theory of narrative transitions as a component of design project work. In doing so, what was learned about the narrative transitions in this reductive approach to the design project through the conversational exchanges in the tutorial?

Let’s begin with an illustration from the topic cluster where a series of utterances are being made by both BL and the tutor, understanding the as discussion being situated around the event structure highlighted in our story grammar framing of narratives, following Franzosi (2004, 2010). Figure 31 provides a simplified illustration of discussion, around the decomposed event structures, where multiple utterances are consolidated to highlight one of the rewrite rules in operation, involving BL discussing a substitution being applied in the project, in order to replace maple with bamboo in his skateboard composition.
In the transcript, BL is attempting to construct a skateboard (the object) but substituting a sustainable one (bamboo skateboard) for the old, conventional one (maple skateboard) which he has outlined as being unsustainable. The event structure in Figure 31 summarises this process, which remains abstracted as a conceptualised event, since the actual substitutions of physical skateboards does not literally seem to be taking place. What is being summarised in this event description, removing the richness of the actual complexity of the space, is that BL needs to bring forward a skateboard he is characterising as being “bamboo”. This involves him producing a physical, material based substitution in the workshop, the outcomes of which he is actually describing throughout this segment of tutorial, through the descriptive “…isā…” statements providing for event orientation by clarifying membership of subjects, objects and actions being accounted for.

In bringing the particular object of a bamboo skateboard into being, the process of rewriting the skateboard through a substitution of materials is causing problems for BL. A straight like-for-like substitution leads to other unanticipated changes. The new skateboard properties, namely, differ from those of the original skateboard made from bamboo, and BL has been required to find a new set of compositions, engaged in an iterative process of re-writing, identifying difference between the physical skateboard he’s made in comparison with the
conceptual skateboard he is hoping to get. In the tutorial, he outlines that he has been “testing”, another event action which allows him to conceal difference in the skateboards with respect to this property of the physical object by determining the appropriate combination of laminations, material thickness, glues, etc. which allows him to match the corresponding properties of the physically present object, what March refers to as “the extant”, with those of “the abstract” (March, 1976). For Deleuze, in his discussion of how difference is mediated through the “4 pillars of reason”, he explains these pillars by introducing similar correspondences, noting material things as determined artifacts, whose properties are determined and fixed by their physically manifested presence. This is contrasted to determinable concepts, the names, types and categories of physical manifestations (the extant), constructing familiar relationships through attribute and property structuring, mapping the conceptual world and the material world onto each other. Bucciarelli simplifies this in suggesting we are constantly moving between “thought and object” (Bucciarelli, 2002).

6.5.2 Constructing a framework: part 2

Moving, as one type of action, is a core principle at the heart of the event — subjects doing with/to other things. Events have come into frame through rules of production which have moved us from project to narratives, and from narratives to events, which was described throughout Chapter 5 and here in Chapter 6. But decomposing to materials levels as in the Grasshopper Skateboards project brings an added dimension which hasn’t yet arisen, the threshold between what appears before us, and what we think is before us. Metaphysics aside, this threshold is an important consideration which moves us from narrative accounts of events to ontological accounts of objects and their properties in comparison with their parallel concepts/types/categories and those associated attributes. When BL returns from the workshop with a physical manifestation resulting from his constructive activities in the workshop, it is
useful to distinguish between the types of production is taking place there, between thought and object. For that reason, the types of productions associated with material modifications are outlined here as rewrite rules, a special type of production rule that involves reconfiguration as well as decomposition.

Rewrite rules, situated at the object level within our examined transcripts, involves changing objects by engaging in a production rule which rewrites their material constituency resulting in a different object set. This approach is illustrated in Figure 32 below.

Figure 32: An Object, decomposed from a narrative event, being characterised, rewritten and uncovering difference

There are two production moves associated at this layer of the framework we are composing. First, something is characterised, that is, a selection of properties are outlined as being pertinent to the focus of engagement and examination, in preparation for rewriting. Characterisation is a form of description, highlighted by “...isa...” statements where extant artifacts are named as part of their membership to the abstract categories that define them. In discourse, however, the use of language provides the facility reveal difference through the addition of particular adjective forms — the bamboo skateboard and the maple skateboard, for instance — which highlights the rewrite production rule at a material level of composition. Characterisation and rewriting are subjected to scrutiny to outline difference revealed, which may need further
rewriting to conceal it, or moving forward with recomposition of the object into events, if the difference outlined is anticipated, expected and desired. This process, iterative by nature and exemplified in other design frameworks through different names, is introduced in this way in its ability to conform to a narrative account of design, facilitating a recomposition upwards from object, into event, and ultimately back into new narratives, understood as one of the overall project goals.

6.5.3 Next Steps

From this position, it might be clear that our framework is expanded and is now able to articulate and illustrate the narrative transitions which were described in the decomposition of the project at the end of Chapter 4. Here in Chapter 6, we see BL engaged in the process of material rewriting as an approach to iterative prototyping, moving materials into objects, objects into events, in an attempt to build a coherent event space. But so far, we have examined this framework application from the position of the design student, perhaps assuming that operation of the production rules is only involved in the space of design practices in the studio and workshop, as if there were only one narrative under consideration. In Chapter 7, I present a second tutorial from a different project, where an object has been characterised, rewritten, returned to the event, and finally shared with someone else, the client, to solicit feedback about the work undertaken by the student in progressing their project. What results is another production rule, involving coherence, which arises when different narrators are introduced to a common event frame, but compose it differently based on experience and points of view. This requires us to consider the perspective of the framework according to multiple narrators.
Consider baggage at an airport check-in station. The spectator may notice shape, size, colour, material and even make of luggage; the pilot is more concerned with weight, and the passenger with destination and ownership. Which pieces of baggage are more alike than others depends not only upon what properties they share, but upon who makes the comparison, and when.

(Goodman, 1972)
7.1 Introduction

Observations, insights and analysis from Chapter 5 led to the construction of a provisional framework adopting a narrative perspective to design practices, decomposing narratives into events, and then further decomposing events into subjects, objects and actions. Guidelines regarding transition moves based on semiotic practices of addition, subtraction, substitution and transposition were outlined and examined in Chapter 6. The approaches adopted in the development of our framework is informally applied from a formal approach outlined as Term Rewrite Systems (TRS) (Baader and Nipkow, 1998, Franzosi, 2010) which highlight the mechanisms of these semiotic moves, through an approach adapted from Quantitative Narrative Analysis (QNA). A diversity of conversational exchanges that are oriented towards characterisations of objects, discussing and moving properties and attributes of determinate things and determinable concepts through the examination of prototypical objects under examination was uncovered. This was understood in relation to object agency, and how difference made regarding objects themselves are a precursor to the narrative transition in the product design milieu. In Chapter 7, we continue to examine the relationship between narratives under transition and their rewritten components to examine the view of these circumstances from the position of the other actors as narrators in the project, and how these other narrators contribute to our evolving framework reflecting on difference.

7.1.1 Lessons Learned

Our opening quote from Nelson Goodman highlights that, despite the same constituent components and events being introduced into a respective frame, the meaning of the frame is construed differently depending upon who has constructed that frame, where, and when.
Whether one is a pilot, or a passenger, a suitcase comes to mean something different dependent upon the frame being employed, and the frame, Goodman reminds us, is valid when considering the person who creates and uses it at a particular place and time. If narratives are constructed by stringing together a particular sequence of events, in order to communicate a particular set of meanings, perspectives, or views, it should be clear that the ordering and relating of events needs to make sense to a narrator, but also to the audience. In short, the narrative requires coherence. Chomsky alluded to this already in his own work regarding transformational grammars, when he presented this grammatically correct, but incoherent sentence clause:

“Colorless green ideas sleep furiously” (Chomsky, 1957).

At this point, our examination of decomposed sentences and examination of event clauses through our adaptations of a story grammar from Qualitative Narrative Analysis (QNA) has not raised any concerns about coherence. However, as outlined at the end of Chapter 6, putting together words to form sentences within conversational turn-taking approaches, incoherence can be identified rather quickly, since the implicature rules which govern conversational turns would be seriously violated, leading to a response requesting clarification, or at least attempting to establish conversational repair (Grice, 1989, Mey, 2001, Levinson, 2016). However, in a strict application of QNA principles, narrative transitions are examined at the event level, in texts which already exist. These texts already demonstrate a high degree of internal coherence as a result of the editorial process, whether implicit or explicit. In our thesis examination so far, events have been examined as units of action themselves, either in relation to past experiences, or to future events anticipated, as part of the project’s development of a narrative transition. However, narratives involve the sequencing of particular, multiple events, whether that be regarding past experiences, or anticipated futures. For this thesis, the sequencing of events outlining actions in time, but also the coherence of events highlighting a change or
transition across time, is a critical dimension of this thesis that deserves attention. In short, if Chapter 5 examined what is revealed when narratives are decomposed, and Chapter 6 examined how semiotic moves were applied to these components in order to rewrite events, Chapter 7 looks to continue examining the narrative transitions by examining how narrative events are sequenced as part of the transition, and how difference is involved in recomposing the new events into the transitioned narrative.

The methodological perspective employed in Chapters 5 & 6, involving decomposition, characterisation, and rewriting, driven by difference, continues to be adopted here in Chapter 7. At this time, a new set of tutorial interactions are presented, where the student and the tutor reconvene following a period of time where the student has returned from continuations of their project development work and has engaged a number of other people in the process to help progress their project accordingly.

Chapter 6 focussed on two individuals in conversation, who at various times adopt the role of narrator. A second set of tutorials, following more than two weeks of students’ progressing their design project away from the tutor, involve catching up on developments, but also contain records of discussions and engagement with others as part of the process of product design development. These others assume a variety of roles in the design project (technician, client, user, colleague, etc), but in the instance where the prototype is engaged with them and their experiences ascertained, they also adopt the role as another narrator, outlining their experiences in narrative form. These various narrator perspectives are sometimes adopted, sometimes ignored, but always provide a new set of events which may need to be sequenced by the students into the shaping of their project trajectory.

In these interactions with others, we see the project and the narrative transition develop according to a trajectory, which may deviate from an understood path depending on new
orientations, brought forward by other narrators and their understanding of narrative events whilst engaged with the prototypes. In this new space, further questions arise regarding how these events where students encounter different points of view and experiences of others confirm or deny project progression. As outlined earlier in Chapter 6, tutorials are intermediary events, in Vinck’s terms (Vinck and Jeantet, 1995, Vinck and Blanco, 2003, Vinck, 2012), whereby not only objects, but other actions and other actors are engaged in either commissioning or mediating project directions and progress.

Here in Chapter 7, we examine difference which manifests itself in various people and their roles within the project, their point of view when assuming the role of narrator, and how narrative events involving a new subject with the prototypical object are understood by the various narrators, and ways in which these narrators help the student and their project construct a coherent project and narrative transition. We begin by reviewing a particularly salient example of a client interaction in the return tutorial session of the Rapid Prosthetics project, following the same practical methods of analysis employed in Chapter 6, based on modularity metrics generated in Chapter 5. The chapter concludes with a discussion on different identified roles, and how difference is understood through this identification and opposition of roles in understanding and constructing sequences of events, based on different experiences of the prototype.

7.2 The Cases: Rapid Prosthetics

Similar to the tutorial interactions presented in the previous Chapter 6, material developments have also been progressing in the Rapid Prosthetics project with student RC. Here, I present a topic segment from the second tutorial interaction which sees RC returning from a meeting with his specialist stakeholder, CM, with a version of his physical prototype for introduction,
inspection and feedback. The network analysis and generated metrics of the tutorial interactions undertaken in Chapter 5 for this tutorial is summarised in Table 12 in Chapter 4. The central topic cluster in the interaction, as outlined by the modularity cluster which contains the node with the highest eigenvalue centrality is thematised as “the client meeting”. The topic cluster, based on modularity, consists of 9 segments connected throughout the tutorial interaction.

7.2.1 Rapid Prosthetics: Session 2

The central statement of the topic cluster, as well as the overall tutorial, with an eigenvalue of 1, is found at L3, made by the tutor. He opens with a form of question asking for an update on the previous weeks developments, asking:

“…and you’ve met with CM.”

This statement by the tutor opens the session, as he seeks to confirm that the client meeting, which was anticipated to have occurred after the previous session, has indeed taken place. The student confirms the meeting has gone ahead, and in following up, the tutor asks as follow on question at L7, wanting to know the views and insights generated from the meeting, wanting to know “what he’s said, about this?”

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>TTR</td>
<td>and you’ve met CM.</td>
</tr>
<tr>
<td>4</td>
<td>RC</td>
<td>yeah</td>
</tr>
<tr>
<td>6</td>
<td>RC</td>
<td>yeah</td>
</tr>
<tr>
<td>7</td>
<td>TTR</td>
<td>what’s he said, about this?</td>
</tr>
</tbody>
</table>

RC responds by outlining that there are a number of factors, but the “prevailing” factor was in relation to the inappropriate scale, the prototype being “far too big”. The added term in the adjective “prevailing”, when seen through our story grammar analysis is an implicating feature, highlighting both plurality of factors raised in the discussion, and the oppositional approach to
the particular factor of scale (“…too big”) implicating difference identified by the client, and conveyed to the student. This difference relation is in comparison between the determinate scalar properties emerging from the prototype presented, and the understanding or experience of prosthetics at a conceptual level and the anticipated attributes that these should have.

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>RC</td>
<td>but the eh ... the prevailing factor was that it was far too big.</td>
</tr>
<tr>
<td>12</td>
<td>TTR</td>
<td>Aahh</td>
</tr>
</tbody>
</table>

RC provides an analysis of the scale question, which itself is a complex question, predicated around impact of the various constituent parts involved in the prosthetic device. Reducing scale uniformly may make some features unusable, or reduce strength through making parts too small and delicate, an observation made in the initial tutorial sequence before the meeting with CM. The tutor confirms the challenges being presented and outlines these may have already been identified by academic tutors in formal feedback during internal assessment procedures.

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>RC</td>
<td>if it's getting smaller again than that probably not something to worry about too much</td>
</tr>
<tr>
<td>92</td>
<td>TTR</td>
<td>but I think, in a way, our, comments from our feedback are addressing that question as well.</td>
</tr>
<tr>
<td>93</td>
<td>RC</td>
<td>yeah</td>
</tr>
</tbody>
</table>

At L103, the tutor makes a remark about the prototype concept, being “…the of thing you don’t put on once …”, a presumed reference to the functionality intended to emerge from the prototypical prosthetic, in a particular context, should it be actually in use. The statement that follows, at L103, returns to a question for the student about the insights and criticisms from CM, outlining a request to understand the work pathways RC hopes to employ in order to address the raised concerns. The question makes a direct reference to composition and ordering of features, implicating a story grammar approach to the task at hand, first to decompose the
prototype into constituent parts predicated on functional features, and then to identify how the
semiotic moves of permutation and reordering might be employed to re-write the overall object
to align the determinable concept attributes and determinate object properties, creating a
coherent link between them

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>TTR</td>
<td>it’s the kind of thing that you don't put on once, unless there is an intruder coming into your house but then you pretty much have other things to worry about.</td>
</tr>
<tr>
<td>108</td>
<td>TTR</td>
<td>so what are the changes that need to be accommodated and how can they be clustered into ways that say that there are other things that are going on.</td>
</tr>
</tbody>
</table>

Further analysis and commentary by the tutor at L147 returns to prototype properties of thickness, highlighting difference through direct comparison to the precedent artifact on which improvements are being made. RC continues to underscore this difference, through oppositional comparison of the representation of the object in the photograph and its scalar attributes in relation to the concretised prototype and the property of scale manifested in physical form. At L53, a further comparison by the student introduces a third object, “…the one he’s got…” enabling a triangulation of comparison in relation to scale between the predecessor artifact held by the student and the prototype which is aimed to develop the artifact further, progressing the narrative transition in the project.

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<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
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<tbody>
<tr>
<td>147</td>
<td>TTR</td>
<td>I must say it’s quite thick though by comparison.</td>
</tr>
<tr>
<td>148</td>
<td>RC</td>
<td>I was trying to...</td>
</tr>
<tr>
<td>152</td>
<td>RC</td>
<td>Because through the photographs that I was looking at it looks quite big.</td>
</tr>
<tr>
<td>153</td>
<td>RC</td>
<td>And the one he’s got, probably closer to the, the actual metal one that I’ve got, then this size.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
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<tbody>
<tr>
<td>209</td>
<td>TTR</td>
<td>I would gather, he’s got two of these right?</td>
</tr>
<tr>
<td>210</td>
<td>RC</td>
<td>No, he’s only got the one.</td>
</tr>
<tr>
<td>211</td>
<td>TTR</td>
<td>So he’s got another hand?</td>
</tr>
<tr>
<td>212</td>
<td>RC</td>
<td>Yeah</td>
</tr>
</tbody>
</table>
At L220, one of the intended features of the new prototype is introduced by the student, “…the pen holder thing…” and outlines how the addition of this feature and associated physical requirements are posing challenges as a result of a scalar dimension concern “…now that I have this extra-half inch here…” The circumstance outlined by RC here is a consequence of CM, the client, examining the prototype, decomposing it and outlining that particular features may function better when considering alternative compositional forms; in effect, the client is now rewriting aspects of the project artifact through permutations, which create challenges for RC in maintaining coherence within the object in relation to other components and features. The discussion about the choice of other possible features, whether through inclusion of added constituents, or substitution of one constituent for another (“…whether we gate in it, or a butterfly nut…”)

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<tbody>
<tr>
<td>220</td>
<td>RC</td>
<td>And with eh, the pen holder thing it's becoming a lot more complicated, now that I have this extra half-inch here he says that, [inaudible] the more controlled that is.</td>
</tr>
<tr>
<td>221</td>
<td>RC</td>
<td>and we started talking about a little thing with whether we gate in it or a butterfly nut, that goes over...</td>
</tr>
</tbody>
</table>

In the final two topic segments of this cluster, the tutor comments on a photograph of CM, and at L263 RC makes mention of a particular component of the prosthetic system, the operating harness, as a “…figure 8 loop that goes over his shoulder…”. This is an aspect of the project which is not being addressed, but needs to be considered as a dependency since it is a secondary device which actually operates the prosthetic when worn. The tutor comments on the photograph again, highlighting the significance of the shoulder harness and its agential relationship to the prosthetic device at L265 when noticing an unassuming task being performed by CM. This harness, similar to the undiscussed skateboard wheels in the previous project, do not become involved formally as part of the project scope, but the impact is felt in that particular components cannot be removed, or altered, without considering the impact of
functionality by the client. In short, the tutor is acknowledging a constraint in the system of operation that suggests it will be necessary to limit the moves available to RC in order to subtract, substitute, or transpose components, without impacting overall system operation.

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<th>Speaker</th>
<th>Utterance</th>
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<tbody>
<tr>
<td>261</td>
<td>TTR</td>
<td>... That's him huh?</td>
</tr>
<tr>
<td>262</td>
<td>RC</td>
<td>aye.</td>
</tr>
<tr>
<td>263</td>
<td>RC</td>
<td>this is part and part of the figure 8 loop that goes over his shoulders, so when he reaches forward [inaudible].</td>
</tr>
<tr>
<td>264</td>
<td>TTR</td>
<td>cool. ...</td>
</tr>
<tr>
<td>265</td>
<td>TTR</td>
<td>that's him zipping up his jacket?</td>
</tr>
<tr>
<td>266</td>
<td>RC</td>
<td>yeah.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
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<tbody>
<tr>
<td>316</td>
<td>TTR</td>
<td>have you asked how often he has to do that?</td>
</tr>
<tr>
<td>317</td>
<td>RC</td>
<td>he does, he doesn't really do it and all...</td>
</tr>
<tr>
<td>318</td>
<td>TTR</td>
<td>have you asked, asked him how much of a bother it is?</td>
</tr>
<tr>
<td>319</td>
<td>RC</td>
<td>no I haven't actually...</td>
</tr>
<tr>
<td>320</td>
<td>TTR</td>
<td>Have you asked him, uhm, what he would think about having to change his hand?</td>
</tr>
<tr>
<td>321</td>
<td>TTR</td>
<td>if it was, I mean, maybe you should ask him about that?</td>
</tr>
<tr>
<td>322</td>
<td>TTR</td>
<td>Instead of saying, you know I've been thinking, I mean he's given you a door to walk through, which is, he's like, aww it's getting too complicated.</td>
</tr>
<tr>
<td>323</td>
<td>TTR</td>
<td>[imitating] &quot;so yeah, how hard is it to change your hand? what if I, kind of made, a couple?&quot;</td>
</tr>
<tr>
<td>324</td>
<td>RC</td>
<td>hmm.</td>
</tr>
<tr>
<td>326</td>
<td>TTR</td>
<td>And then suddenly, he's he's working for you.</td>
</tr>
<tr>
<td>327</td>
<td>RC</td>
<td>hmm</td>
</tr>
</tbody>
</table>

The topic closes with the tutor asking the student about his ability to interrogate CM about how he makes use of his prosthetic hand. The tutor is asking RC whether he can make use of the complexity within his project development to generate multiple artifacts which might address different combinations of functions, through enlisting CM as the subject to explore his own relationship with assorted prototypical objects, in essence, allowing CM to experience these devices, and recount his own narratives of experience to allow RC to progress and develop the appropriate prosthetic prototype further, with the implication by the tutor at L326 that in doing so, “...suddenly he’s … working for you”.
In summary, this topic segment from the tutorial interaction in the Rapid Prosthetics project brings the direct experiences of another subject into the story grammar frame, whereby RC has provided a platform for CM to report back to him on his understanding of his experience of the current prototypical form. The conversation with the tutor now involves the extent to which CM’s narrative aligns with the transition RC is attempting to develop and put in place. With the introduction of CM’s accounts to the tutorial session, difference as the underlying mode of representation is again revealed, recalling Deleuze’s framing of difference from Chapter 2 (Deleuze, 2014). For CM, difference through opposition is evident between his experience of the prototype, compared to his experience of his own prosthetic hand, whereby the two determined objects are familiar, but with an underlying distinction between them on the property of scale. This issue of scale becomes a challenge to the overall prototypical development since scale impacts different functions and structures in different, unanticipated ways.

Within the tutorial, other topics of conversation not covered in this cluster reveal more clearly the impact of scale on function:

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<th>Speaker</th>
<th>Utterance</th>
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<tbody>
<tr>
<td>33</td>
<td>RC</td>
<td>Because when the other one is as well it starts to become, quite limiting to the way he holds cutlery, pass it through here and then through these prongs</td>
</tr>
<tr>
<td>42</td>
<td>RC</td>
<td>when he was talking to me about it he said that the scenarios for reaching out of a car window to grab paper are so infrequent that it is possibly not worth doing it.</td>
</tr>
<tr>
<td>47</td>
<td>RC</td>
<td>the point is actually helpful for, for ah, pressing buttons and stuff like that.</td>
</tr>
<tr>
<td>53</td>
<td>RC</td>
<td>I have got this sledgehammer handle I have been testing testing it with to see if it was the right diameter for it to pass through.</td>
</tr>
<tr>
<td>55</td>
<td>RC</td>
<td>I should be having, this thing that supposed to be to, too small for it to pass through so when he closes it he is got a grip on it.</td>
</tr>
<tr>
<td>68</td>
<td>RC</td>
<td>he wants a bottle opener on the bottom of it and stuff like that.</td>
</tr>
<tr>
<td>70</td>
<td>RC</td>
<td>I mean it is getting smaller but it is getting, very, very complicated.</td>
</tr>
</tbody>
</table>
At L71, RC raises his concern regarding this challenge, based on two competing narratives requiring to be aligned, in response to the various choices he has, as a designer within his established project scope:

<table>
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<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>RC</td>
<td>I do not think, I do not agree with some of the things that he is requesting.</td>
</tr>
</tbody>
</table>

From our story grammar perspective, we could rewrite the challenges between the inclusion of functional attributes and the impact on scalar properties, into a set of event clauses as presented in Figure 33, and outlined below:

\[
\text{event} \quad \rightarrow \quad \{\text{subject}<\text{action}>[\text{object}]][\text{time}][\text{place}]\}
\]

RC talking about his designing:

\[
\rightarrow \quad \text{"I", "have included", "these features", "but"}
\]

\[
\rightarrow \quad \text{"He", "would like", "other features", "and"}
\]

\[
\rightarrow \quad \text{"He", "would like", "it smaller"}
\]

Figure 33: An example of event clauses and decomposition from Rapid Prosthetics

In this story grammar framing, the significant substitution again in this follow up tutorial is at the subject level, reporting what was said by another speaker. Regarding the object substitutions, difference between two sets of object properties (scale, function) have an impact on the overall form, requiring alternative developments in composition and further rewriting by the designer, which is based primarily on the new speaker or narrator having outlining their experiences of difference between determinable concept attributes in their understanding of the concept associated with the prototype, and the actual properties displayed in the determinate object as prototype in their midst. Similar to the previous tutorial, difference is needing to be managed not necessarily in the oppositional determinates between objects, materials and their associated properties, as it is between the determinable conceptions about experiences and
events within relationships between subjects and objects, when narrative events are unfolded from the perspectives of new narrators and multiple subjects.

## 7.3 Analysis and Discussion

In this chapter, our analysis using a story grammar framework adopted from Franzosi’s QNA method was employed on subsequent tutorial interactions between the postgraduate product design students and their studio tutor, following a period of development work undertaken by the students away from the tutor. In these subsequent sessions, other actors are introduced to the episode who have had an opportunity to see the work in development and provide an alternative point of view, operating effectively as new narrators, contributing to the narrative transitions within the project scope. Whereas in the first set of tutorials the primary forms of rewriting were based at the object level following decomposition, in these tutorials the new actors provide new perspectives with insights into narrative transitions, requiring reflection on the impact of substitutions of a different subject within the narrative event frame. In this chapter summary, we consolidate the particular observations generated from the analysis of the individual sessions in our case studies to contribute to the common framework that we have been developing across this thesis, understanding design projects fostering narrative transitions, driven by reflecting upon difference.

### 7.3.1 Roles: The Narrator

Throughout all tutorials which have been analysed as part of the dissertation, references to other people are extensive. Technicians in workshops, tutors in other studios, classmates, clients and other stakeholders with some interest and involvement in the project are brought into the conversation. These other subjects provide alternative points of view, with particular knowledge related to the prototypes under development in the student project and are enlisted
to help progress projects and narrative transitions in some way. The case presentation of the tutorial discussion Rapid Prosthetics provides useful insights into new aspects of narrative transitions supported by our emergent framework, namely the role of other narrators, composing different narratives.

When RC presents the prototypical prosthetic to CM for his consideration, he does so knowing that CM, as a prosthetic user, has a great deal of personal experience that RC necessarily lacks since he is does not require a prosthetic device. The introduction of the artifact into the client meeting, taking place between the captured tutorial interactions in the studio with the tutor, is an example of the rich interactive circumstances that has received significant attention from scholars of Science and Technology Studies, some of whom were introduced and briefly discuss in opening chapter in Section 1.2, highlighting the importance of rich media devices involved in communicative, knowledge and work flow exchanges. Key concepts which have made significant contributions in this area include understanding physical artefacts as boundary objects (Star et al., 1989, Star and Griesemer, 1989, Leigh Star, 2010), which afford interpretive flexibility amongst participants in their understanding of the object, but also provides a mechanism to structure and organise work flow activities amongst those engaged with the object. Vinck provides an extension of the concept of the boundary object relevant to engineering design and practice, referring to his artefacts as intermediary devices (Vinck and Jeantet, 1995, Vinck and Blanco, 2003, Trompette and Vinck, 2009, Vinck, 2012). Vinck outlines that the concept of boundary object is limited in one perspective, being unable to account for significant physical changes and materials adaptations involved with product development involving prototypes, a circumstance at the heart of engineering design.

The prosthetic hand that RC introduces to CM in their meeting has features of both boundary objects and intermediary devices. RC has committed to work and development based on his experiences with CM, attempting to understand what he refers to as “his daily routines” and
ways in which he may improve the antiquated prosthetic device by fostering new types of interactions in a variety of situations. The situations RC describes are events themselves, outlined in utterances making reference to “holding a pencil”, “swinging an axe”, or “pressing the screen”. The diversity of these events are tested against a new prosthetic device which has been characterised and rewritten in terms of shapes and forms, in contrast to BL who has been working primarily in materials. RC is employing an added rewrite rule in permutation, or transposition (Chandler, 2007), involving changing locations of constituent parts through a special move akin to subtraction, then addition, but in a new position. These rewrite rules cause implications for RC, in that particular shape rewrites impact different event actions in different ways, when the rewritten object is returned to the event frame to understand its relationship to the subject engaging it at another unspecified time.

The introduction of the device to CM, however, highlights new information and new perspectives based on the encounter and prior experience CM has with similar devices in everyday situations. He is able to outline from his past experience of circumstances unfold, and is able to anticipate challenges to these event interactions which RC is unable to see, making the artifact projection into future events problematic. CM it would appear, is also engaged in our framework cycle of decomposing the narrative that RC has provided him with the new prosthetic object, breaking it down into his own understanding of event structures, and highlighting that the encounters between subject and object in these different times and spaces are problematic. Difference emerges in that the attributions afforded to the events which the object carries upwards based on the outcomes of rewrite rules being employed by RC do not cohere with the interpretations arrived at by CM. CM also sees different constituent events arising from other different story configurations in his day; going to the gym, doing yard work, using a bottle opener. RC outlines his frustrations in being unable to accommodate everything that CM is hoping for, since the requests are making things “too complex”. RC is struggling
with an overload of decomposition activities from CM that and competing and conflicting with his own interpretations, and he is struggling to understand how to make sense of the situation and bring coherence across the narrative divide, as the role of narrator is rotated by RC as designer, and CM as client.

7.3.2 Extending the framework (Part 3)

The opening section of this chapter outlined the position of Chomsky in realising that strict adherence to a context-free transformational grammar has the potential of resulting in ambiguous sentence constructions that do not display coherence; they simply make no sense. In our tutorial interactions, we see the importance that coherence plays in conjunction with recomposition, two other production rules in our emerging framework that highlight the importance of difference when multiple narrators are involved in engaged in narrative transitions, represented through rewritten objects resultant in developments taking place in the product design studio. The desire for coherence becomes apparent in the revealing of difference across multiple narrators, but in the studio frame we are left with the narrative recollection of the experiences from those interactions, highlighting the challenges inherent in the student frustration, with respect to the amount and degree of difference he is trying to contend with as the new narrator employs a similar framework, with significantly different results, due to the relationship between past experiences and different sequences of events in a different space and time, inevitably shaping localised approaches to production rule application by particular individuals which do not correspond to more globalised expectations across narrative terrain. The entanglements of decomposition strategies highlighted by this episode from the tutorial exchange is found in Figure 34 below.
7.3.3 Next Steps

In this chapter I have attempted to outline the need for and the challenges associated with recomposition and coherence, following object characterisation and rewriting, when multiple narrators are involved in the product design process viewed through a narrative framing. The narrative mode of discourse is involved in making meaning from the past experiences by sequencing together salient events which comprise the story, and each narrator brings with them an individual context to the composition of narratives employed through a story grammar frame. This return process of putting the new narrative back together is more complex than simply slotting things in, since coherence is required which allows multiple narrators to understand the event and subsequently the narrative as making sense. Having provided an illustrative account of that segment of the process, it remains to consolidate the findings and insights from across the chapters in order to provide a holistic perspective of the process, which will be done in the subsequence chapter 8, whilst also accounting for the formal introduction.
of the mechanisms associated with reflecting on difference, evident through the generation of various texts within design project transitions.
Chapter 8

The Design Difference Framework: a discussion

Representation fails to capture the affirmed world of difference. Representation is only a single centre, a unique and receding perspective, and in consequence of false depth. It mediates everything, but mobilises and moves nothing. Movement, for its part, implies a plurality of centres, a superposition of perspectives, a tangle of points of view, the coexistence of moments which essentially distort representation: paintings or sculptures are already such “distorters”, forcing us to create movement — that is to combine a superficial and a penetrating view, or to ascend and descend within the space as we move through it.

(Deleuze, 2014)
8.1 Introduction

Chapter 8 brings together the findings from the analysis of tutorial interactions, and the case study accounts of product design projects, into a unified framework that describes the practice of a product design project, predicated on a narrative transition, involving decomposing, characterising, rewriting, cohering, and recomposing, driven by reflecting on difference as the framework is enacted. The Design Difference Framework (DDF) is introduced, as a consolidation of work and observations developed in Chapters 4 through 7. Here in Chapter 8, the framework presented is a generalisation of findings, developed from observations of the particulars each of the three case studies, all displaying unique narratives in transition, but arguably operating in a similar premise which this framework aims to describe.

Chapter 8 introduces and discusses the Design Difference Framework (DDF). It will itself be broken down into the 5 key steps, each to be discussed in turn, under the auspice of a narrative design thinking model. The overall framework and the 5 key steps, is outlined in Figure 35 below.
Figure 35: A provisional design-difference framework highlighting narrative production rules inside the design project
The DDF framework compiled and to be discussed involves 5 key phases:

- **Decomposing**
- **Characterising**
- **Rewriting**
- **Cohering**
- **Recomposing**

Across all phases, “design moves” are summarised as an implementation of production rules, an approach adopted from Term Rewrite Systems (TRS) perspectives, and highlighted as directional arrows through the framework. The production rules are employed to move the project forward, through analysis of the conditions of the current state and implementing an appropriate action which provides for the move to a new conditional state to occur. This perspective resonates with the general definition of design put forward by Simon (1996). However, the process of production requires reflection as opposed to verification, since the semiotic moves involved with this approach introduce difference between determinate extant objects and determinable, abstract concepts involved in the narrative transition. Understanding reflection as key competency within design practice is generally attributed to Schön (1983), and has seen a great deal of attention within both this thesis, and the design research literature in general (Dorst and Cross, 2001, Adams et al., 2003, Cross, 2007, Hutchinson and Tracey, 2015, Baaki et al., 2016).

### 8.1.1 Overview

Chapter 8 consolidates the exploratory findings from our case studies of student design projects into the framework illustrated in Figure 35, drawing from each chapter which described and discussed various layers of activity as the project became progressively decomposed, and provided a summary illustration of that layer of activity at each chapter conclusion. This
consolidation and the relationships between these layers of activity in the framework requires further explanation and clarification in this move to consolidate these findings.

Section 2 provides a detailed discussion of our preliminary Design Difference Framework, outlined as a design framework predicated on narrative thinking, based on our examination of our preliminary research question and the 4 thematics of design projects, narratives, reflection and difference. The framework remains theoretical, drawn from our empirical examinations of student designers in training, through intermediary points in their individual projects, discussing the project trajectory with their tutor. The nature of product design projects is discussed as moving between the assorted layers of the project through the application of various rules of production allowing: 1) decomposing whole units into their constituent components, moving to the subsequent layer of analysis; 2) characterising determinate extant objects in their relationships to their commensurate determinable abstract forms; 3) rewriting the object through semiotic moves; 4) recomposing constituent parts back into wholes, and 5) cohering constituent parts together through a realisation that recomposition makes sense.

Section 3 discusses the framework in the context of narrative thinking and knowing structured in difference, where design is actively engaged in the production of a transition in addressing difference. Multiple narrators shows multiple perspectives and multiple approaches to the production rules approach depending upon context. Characterising, rewriting and cohering, it is argued, is not isolated to a particular object layer, but is actively engaged at all layers of the framework, taking into account that production rules are themselves actions, taken by whereby subjects and objects are syntagmatically re-ordered across the narrative event. A conundrum arises, however, in that production rules are actions taken by the design student themselves, leading to the insights from Chapter 7 involving multiple narrators engaged in the process, employing their own production rules to contribute their understanding of the narrative transition.
Section 4 concludes this chapter, reflects critically on the DDF framework and outlines the remaining challenges that may need to be considered for future development.

8.2 Difference by design: a framework

The 4 phrases of the Design Difference Framework, illustrated in Figure 35 is explained here, as well as the premise of design moves being understood in semiotic terms, employed as a collection of rewrite rules in a situated term rewrite system (TRS) employed by the design student and fostered by the tutor within the student tutorials and across the student project.

8.2.1 Decomposing

The first phase in our framework is involves a production rule denoted as decomposing. Decomposing is defined as:

\[ \text{To separate or resolve into its constituent parts or elements. (Of the separation of substances into their chemical elements, of light into its constituent colours; also of force or motion).} \]

Decomposition was first outlined in Chapter 4, when presenting one rationale of a design project as an activity involved in a transition of a narrative, outlined as ΔN. This was subsequently understood as a set of actions moving the current narrative to a preferred one, situated around the interactions between people and the object or product being designed. Chapter 4 concluded with an outline of each of the case studies of student projects The informal, common sense approach to coding the transcripts in Chapter 5, leading to linkographs and social network graphs through Gephi, employed an approach that involved parsing of the text intuitively into components within each utterance based on what was being discussed: people, actions, objects, locations, times, and so forth. The reason that an approach to

\[ \text{Oxford English Dictionary online, accessed on Jan 24 2021} \]
linkography specifically, or networking in general, was a result of parsing being the only step evident in the conversational transcripts under examination. Decomposing in and of itself is a reductionist activity, however, the practice of linking the narrative constituent components across utterances resulted in a researcher driven paradigm where linkages are established based on the coding scheme being situated within the text itself, uncovering the narrative and its topic clusters and segments, without understanding how the narrative ultimately transitions over time.

Decomposing is evident in all three of the case studies presented, whether that is articulating the various components of a skateboard and its material composition, the forms and features of a prosthetic hand that emulate operations of an actual hand more succinctly, or the features of a doll that afford sensory capture and recording to share with parents as children learn to navigate the world with independence. Despite the approaches adopted in these projects, it is likely that other students might have engaged a similar project through different decomposing strategies. As Harfield points out, it isn’t so much that there are multiple solutions to a single project brief, it is perhaps equally relevant to suggest there are multiple interpretations to a project brief leading to a plethora of solutions (Harfield, 2007). In this way, decomposing remains a simplified strategy for “taking things apart”, which in a narrative frame is easy to identify, because it would appear, according to Bruner, to be the mode of thinking that is suited to understanding experience and meaning, rather than ascertaining truth, through causality (Bruner, 1991). Decomposing is also useful in that it moves us from the general to the particular, a key feature of narratives and their structure, as outlined by Riessman (2008). In this regard, decomposing is an approach that moves us from a comprehensive unit of analysis to the set of components that define the larger unit, whether this be in Chomsky’s transformational-generative grammar where sentences are decomposed into various noun and verb phrases (Chomsky, 1957), Alexander’s deconstruction of an electric kettle into function,
shape, form and material (Alexander, 1973), or an established coding scheme used by researchers to identify thematic patterns in interview transcripts (Saldaña, 2013). In the narrative mode of thinking, the decomposing scheme is already embedded, as has been outlined in our move from narratives to events, and events to constituent parts of actors, actions, time and place (Todorov and Weinstein, 1969, Greimas, 1971, Labov, 1972).

Once decomposing a comprehensive unit into its constituent parts has been done, and those constituent parts become the new units of analysis, decomposing can take place again, allowing for finer grained levels of detail and increasingly more specific units of analysis. Within the framework proposed in Figure 35, built upon the observations and analysis of discourse interactions in the product design studio, we have outlined three levels of decomposition, when applying the ethos of Franzosi’s story grammar approach from QNA (Franzosi, 2004, Franzosi, 2010). In our empirical case studies, further levels of decomposing might be argued for, whereby product design projects, decomposed twice to the level of objects inside events, might readily be decomposed one further time to a material level. This is summarised in the notations captured in Figure 36 below.

![Figure 36: Summary of narrative decomposition within the difference design framework](image)

**8.2.2 Characterising**

However, decomposing into smaller materials involves something more than simply decomposing, since the discussion moves between the idea of objects of materials their substantive form, as participants in the tutorial frame. This movement introduces our second phase in the framework, that of *characterisation*. Whereas Event clauses are under discussion,
they do not present themselves in material forms during conversational exchange. Objects and materials, such as bamboo and maple skateboard decks, plastic and metal prosthetic hands, and fabric and textile dolls laden with electronics, involve negotiating between the substance of things in the scene and their determinate object properties, as well the essence of things and our conceptual understanding of the object and its determinable, categorical attributes. The mapping of attributes associated with a family of objects onto the properties of those physical instances in the world allows to determine family membership, relationships and associations with other things in the world.

Characterising is defined in the OED as:

1. To engrave, imprint, inscribe, or write (words, symbols, etc.) on or in something; to engrave, imprint, or inscribe (a surface, material, etc.) with something; also figurative and in figurative contexts.

2. To represent, symbolize, portray

Characterising becomes evident when the discussions between the students and tutor move between what objects are, and what they do. It starts with constructing a relationship between the abstracted logical forms of the conceptual object and the extant physical presence of “in-the-world” things around us, as March (1976) outlined for us in Chapter 6. Characterisation is a readily identified action in the framework, seen in the presence of the …isa… statements highlighted in the story grammar analysis in Chapter 6, which are nominally described by Labov (1972) as orientation clauses in his grammar of narrative experience; for Bucciarelli, it involves naming (1988).

Characterising is seen early in all the tutorial sessions, most notably after prototypes, artifacts and materials have been introduced. A skateboard is introduced in the Grasshopper Skateboard

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project, named as a construction of laminated maple veneer, extracted from the narrative involving the unsustainable skateboard. In the tutorial we are also introduced to other materials, characterised as bamboo, jute hemp, eco resin, titebond, wax paper, plastics, grip tape and more. These are more than things being named, I suggest, since the extant materials are understood as such based on their physical properties, and also in relation to the attributes associated with the abstract material within the concept category. The materials presented and characterised as bamboo and maple are discussed in terms of the properties of strength, stiffness, texture, which are all considered in relation to the abstracted materials which provides them with their names, as wood veneer types. Other objects are introduced to the tutorial, through different stories and different topics of conversation: the surface planar (L71) and the drum sander (L73); the vacuum bag (L79) and the clamping press (81), all various machines located in the workshops at other places beyond the space where the tutorial unfolds. These objects themselves conform to a type (machine) that in other narratives might be decomposed further (into constituent parts of motors, blades, casings, etc), but here are characterised by the activities they perform through the engagement by the student in the workshop.

Though not formally introduced in the micro level examinations of tutorials in the earlier chapters, the first session of the Rapid Prosthetics project, characterisation is also evident, taking place with the introduction of a particular prosthetic (“L34: “...the farmer’s hook...”), and the anticipated approach to initial rewriting through modelling and prototyping in particular materials, such as blue foam, in contrast to CIBA tool. The characterisation involves the various properties of these prototyping materials in question, notably hardness:

*L46: There’s a harder foam than blue foam*

These properties of hardness correspond to a rewriting exercise which involving the attributes of shape in the anticipated abstracted prototypes yet to appear which are characterised as having intricate and delicate components in the prototype itself (a further decomposition having taken
place regarding the prosthetic itself into necessary component structures). Hardness of material
also corresponded to other attributes of the two materials under comparison, notably
workability as well as price, with an inverse relation between these determinate properties in
both these extant objects.

The third case study followed was called Comiconnectors, introduced in the case studies of
Chapter 4, but not discussed in our micro-level engagement with tutor-student interactions.
However, when examining CT’s project and her narrative transition involving child-parent
attachments, characterisation becomes a significant activity on a variety of levels. Having
decomposed the objects into fabrics, buttons, threads, as well as electronic parts, the
recomposed shapes become characterised as pets and friends: sewn shapes come to be
identified as various kinds of animals in the second tutorial session, including an owl, or a cat
(L32), or a terrier, which might be confused with a bear (L37). They are further characterised
in their interactive relationships with kids, named as friends (L189), indicative of the role they
hold in the relationship. The challenge for CT involved the alignment of the physical properties
of the determinate objects, the shapes, forms, textures and features, assembled together to
resemble the determinable concept of the doll as a friend. Similar to RC, the question of
function becomes critical, whereby determinate properties of extant electronic sensors become
analogous to the abstracted sensory features of actual sentient beings; a vibrating motor
emulates the condition of a beating heart (L71); a digital camera enables the character to see
(L86); an audio recorder enables another to hear and listen (L83). These associated attributes
of the figures when characterised as friends, such as their eyes, ears and mouths, requires
consideration of the corresponding properties of the sensors to complete the characterisations
in an appropriate manner. Another characterisation involves the relationship to object and
material properties involving shape, form and texture, and their correspondence to the attributes
of friendly things.
At the object layer, the production rule of characterising, notably between extant material and the abstracted concept is a significant introduction to the variety of physical instances of things in the product design space. Whether it be characterisations wood types, named either as bamboo or maple, in modelling materials named either as blue foam or CIBA, or in a family of interactive fabric dolls outlined as being particular types of animal friends named as owls, dogs, and cats, the process is quick and almost automatic. Leaving behind serious concerns about metaphysical conundrums of understanding the presence of a singular, homogenous object, the process of characterisation is critical for making things particular and in preparing for the next production rule activity in the framework, involving rewriting, which is discussed next.

8.2.3 Rewriting

The rewriting layer of the framework introduces a production rule involving an alteration of the object through a series of semiotic moves, the basic being adding and subtracting, with two extended moves being substitution and permutation. These moves involve making some change, whether it involves the determinate extant object, or possibly the determinable abstract concept, with both approaches introducing difference which is identifiable in the “4 principles of reason” outlined by Deleuze in Chapter 2 (Deleuze, 2014). A distinction is made between the production rules of decomposing/composing, and the production rule of term re-writing, which might seem superficially similar. Decomposing involves reducing an abstract determinable unit, such as a narrative, into syntactical components based on a transformational grammar being applied. Rewriting rules differ from decomposing through grammars in their ability to manage syntactical and structural ambiguity which often result from decomposing, in moving between abstract concepts and extant things considered members of the abstracted

I’ve already outlined that Franzosi’s QNA is a special example of a modified TRS in action, since it involves the application of a transformational grammar in order to decompose texts into constituent components (event —> subject object action), in order to identify across different texts how the grammar has been rewritten through identifying shifts in particular word usage to describe an historical event when accounted for from the perspective of multiple narrators. Rewriting involves the availability of specific terms (known as terminals) which might be used to describe the events under examination, leading to different descriptions of a presumed common event, and thereby changing the narrative. Using newspaper articles which are reporting on a set of common historical events and circumstances, Franzosi can track how these events are reported differently by various newspapers at various times, by various narrators, through their alternative deployment of particular (i.e. determined) constituent parts within the story grammar frame, leading to insight about narrator intentions in directing the narrative in a particular direction. In short, rewriting allows for the ability to account for the modification or variability of application of the story grammar rules in action.

However, our framework is particularly concerned with design activity generated within the educational context of postgraduate product design, as opposed to journalism. A significant distinction is that design, as Simon points out, is about actively moving the existing state to a preferred one (Simon, 1996). In our thesis examination of the tutorial protocols, the use of rewrite rules in the design tutorial highlights these actively engaged moments, whereas in Franzosi’s QNA the degree to which rewriting is actively intentional is unclear, and is perhaps drawn out over time and place, being impacted by other contextualised circumstances. But what is this active rewriting doing? In moving between the abstract concept, and the extant object, characterisation highlights the degree of fit, particularly multiple extant objects are
under consideration. With this in mind, I argue that the interactions between the student and the tutor highlight rewriting as change in either concept or artifact. This change, modification, or rewriting, in practice, brings about difference, between our understanding of abstract concepts and perception of extant artifacts, through the adding, removing, and rearranging of extant artifact properties, through prototyping activities between tutorials, and comparing and contrasting these to the abstract object attributes which define the categories of which these artifacts are considered members. This was illustrated in the detail image of the object layer interactions, introduced at the conclusion of Chapter 6 through Figure 32.

The tutorials are based in a postgraduate product design studio, employing a project-based learning (PBL) approach to design education, and a plethora of materials and artifacts, already characterised, are involved in intermediary tutorial discussions. Rewrite rules are easy to identify in the event clauses in all tutorial transcripts. In the Grasshopper Skateboards project, BL is making a material substitution for maple with bamboo in his skateboard deck construction, and application of this rewrite rule introduces difference in opposition. Both materials have shared membership within the overarching category of wood types, both possessing attributes of strength, flexibility, texture and above their degree of sustainability, revealed through their respective characterisations. However, the extant physical materials demonstrate different properties in relation to these attributes, by degree, suggesting that a direct substitution of the bamboo for the maple during rewriting will have an impact on the overall object, both physically and conceptually. Possible material remedies to this are discussed, in order to maintain that any new composition involving alternative materials remains true to the character of the new board, being both sustainable, but not lacking in strength. Managing the interplay between strength as an attribute of the concept of the skateboard, which the properties of the substituted materials cannot account for in terms of decomposing alone, involves the iterative practice of rewriting across these two spaces of the
extant artifact and the abstract object, operating as a multiple order boundary object (Star et al., 1989, Star and Griesemer, 1989). For BL, he is attempting to rewrite both the skateboard concept in his original project scope, transitioning the narrative from sustainable to unsustainable. This narrative transition involves managing between a variety of comparisons, particularly between the actual properties of any new composition he intends and the one he is able to realise.

Whilst BL is engaged rewriting a skateboard through introducing or removing various materials, RC is attempting to rewrite the conceptual prosthetic, and its relationship to the form and shape in the concretised prototype. In the first tutorial, characterisation played a more significant role, noted by the presence of drawings, in lieu of physical artifacts and materials, which appear primarily in their conceptual, determinable forms. Between tutorial session, a series of objects have been made, in an assortment of materials, and these have also been presented to CM, his client, who is asked to examine the utilitarian functionality of new, extant artifact in the prototype. These activities discussed in the 2nd tutorial session range from clutching paper (L42); pressing buttons (L47); or using a chainsaw (L58). As the original prosthetic struggles to facilitate writing, yard work, gym activities and the opening of bottled beverages, rewriting has led to shape changes by RC which require adjustments to other shapes and forms inside the new extant object. The rewriting of shape impacts other shapes, which impacts functionality, highlighting difference across the same abstract object attributes, now in opposition to the extant object properties. Difference in thickness in some features becomes a concern despite the proposed shape composition affording other functional facilities, such as a pointed tip allowing for pressing buttons, or clutching paper. A homogenous view of the experience of these activities, though determinable in thought, remains elusive when determined in materialised form, leading to multiple attempts at characterisation, followed by rewriting, revealing other forms of difference.
In Comiconnectors, CT begins rewriting in significant substitutions at a material level, including the fabrics associated with the shapes to be constructed which must be cut according to a pattern, stitched, stuffed, and then filled with electronics. In these moves the properties of the extant shapes are added to, subtracted from, and rearranged, and then subjected to an examination of the attributes of the abstract concept object in the transition to dolls as friends, in association with the properties extant artifact creations that exemplify these attributes in their material properties. Characters are rewritten to have big ears with microphones that enable listening, big eyes are cameras to allow seeing, and big mouths contain speakers to foster speaking. The attributes of the abstracted electronic devices are outlined, and correspondence is sought with the properties of the extant objects being generated. The dolls themselves, when analogising their various anatomical parts in determining their shape and function is a further process of decomposition, highlighting that dolls are first order objects but can be decomposed further, when necessary, similar to the further object layers made evident in the Rapid Prosthetics project.

In summary, if characterisation is evidenced in the utterances in the tutorial sessions through the presence of naming, and the “…isa…” verb phrasing, rewriting is to be found in the material actions that bring about some change, whether that is making, shaping, forming, building, carving, printing, sketching, and so on. These rewriting actions are easily evident in the transcripts with students in the workshops and studio engaged in the concretisation of their project outcomes as extant artifacts, which are required to be reconfigured and aligned so that some aspect of their characterised properties aligns to the earlier rewritings of the abstracted conceptual object which was reconfigured during the narrative transitions, through modified events in order to address the new narratives as project goals. This rewrite process can go in either direction, where a new extant artifact, not yet identified, requires a rewriting of the abstracted conceptual objects to accommodate something that has not yet been identified.
Though this process is entirely possible, it was not identified in the projects or protocols examined, perhaps on the basis of the nature of the projects undertaken and guidance given by tutors in concretising outcomes of projects, rather than speculating on abstracted concept futures. In either case, whatever is rewritten, the outcome of the action needs to make sense, in other words, the intended consequences and the actual consequences of rewriting need to cohere, discussed as the 4th layer in our presented framework.

8.2.4 Recomposing

Once characterisation and rewriting have taken place, the framework moves to the next production rule involving recomposing. If decomposing is the process associated with breaking things down into their constituent parts, recomposing is the process whereby individual elements are combined to create a new whole. If decomposing is about taking apart, recomposing is nominally outlined as a practice of putting things back together.

Recomposing, the phase in our framework that moves us from individual components like objects, towards a larger, aggregated unit involving relationships between parts (like subject-object events) is evident in tutorial interactions from our case studies as students examine and discuss how rewritten objects come to fit back in the new event frame, leading to the changed narrative as part of the transition within the project. In our cases, recomposing is evident early in Grasshopper Skateboards first session, with the introduction of the first set of material prototypes, identified as a skateboard (L15), and then a second material prototype introduced, yet identified (through difference) in opposition with the previous one as a result of the different materials used to compose it, and its relative strength by comparison:

\[\text{L33 S: } I \text{ think bamboo is stronger}\]
Recomposing is also apparent in the actions under discussion between BL and the tutor, namely the discussions regarding approaches to laminating, which involves a series of actions including preparation of materials (L73); application of adhesive, and then insertion into a vacuum bag for pressing (L75; L85). The activity of testing to be undertaken also involves the chunking of activities, namely a sequence of specific tests, including flex, shock, and accelerated life testing to assess wear and tear (L179-204).

The approach to recomposing in the Grasshopper Skateboards Project, however, doesn’t move towards the reconstruction of events in the narrative transition within the two tutorial sessions with BL and the tutor. The timeline of scheduled meetings and the progression of work only encapsulates technical meetings, and in these discursive sessions we are not introduced to any completed prototype which is available to act upon. Only much later in the project, after samples have been tested, a skateboard deck constructed and the wheels added, is BL able to introduce the board back to a series of events which move the narrative transition forward, as evidenced in his design book, discussed at the end of Chapter 4, where he allows a professional skateboarder to use (and abuse) his prototype as part of a user-testing and feedback session. In contrast, the other two case studies have demonstrated more direct interaction with eventual end users and clients in their projects, with recomposing evidencing itself in the transcripts of those tutorial interactions and project developments in other ways.

In Rapid Prosthetics, the first tutorial with RC highlights his attempt at recomposing through a discussion of functional features to be incorporated into an improved prosthetic device, which he feels is a core component of his overall project scope. Having decomposed the narrative associated with his client CM’s daily life into sets of actions and routines, RC has already identified a set of functional attributes that he hopes to feature into the shape and form properties of his prototype prosthetic device. In the second session, these features are discussed more explicitly, and their relationships to particular shapes and forms are highlighted in the
types of events in which they might find themselves. RC discusses a shape concern in his determinate object prototype that may impact future actions in a set of determinable events:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>RC</td>
<td>when he was talking to me about it he said that the scenarios for reaching out of a car window to grab paper are so infrequent that it is possibly not worth doing it.</td>
</tr>
<tr>
<td>43</td>
<td>RC</td>
<td>And really, that is a, operation very easily done with the other part.</td>
</tr>
<tr>
<td>44</td>
<td>RC</td>
<td>Ehmm, something I wanted to change in the first place was this was too thin and this bit was too thick.</td>
</tr>
<tr>
<td>45</td>
<td>RC</td>
<td>as soon as it came out of the machine I could tell that.</td>
</tr>
<tr>
<td>46</td>
<td>RC</td>
<td>He said the same thing, but also that it should poke around slightly further and come to more of a point.</td>
</tr>
<tr>
<td>47</td>
<td>RC</td>
<td>the point is actually helpful for, for ah, pressing buttons and stuff like that.</td>
</tr>
</tbody>
</table>

Here, recomposing involves placing the new object into a variety of event frames (L42) whereby the considerations of event actions in future narratives might be considered, based on the prior experience of CM. Grabbing and pressing become two key operations that are recomposed action words at event level, underlying a sequence of smaller events that involve activating the prosthetic, positioning it in proximity to another object, and then engaging with it in some manner (i.e. grabbing). These events being discussed are not only instances of an isolated action as abstracted in our story grammar approach, but rather involve a shorthand for a particular sequence of situated events involving determinable future times and places where the determined extant artifact, represented in the prototype, is being used. In this perspective, RC is recomposing together particular features and functions within the prototype he has shared with CM into the action oriented events to understand and anticipate eventual operations, and transfer that understanding in a reconstituted and recomposed event frame format.

If the Grasshopper Skateboards project evidences the production rules of recomposing in the transition from characterised materials into named objects, and the Rapid Prosthetics project is recomposing characterised objects and their functional properties through replacing them into a consolidated sequences of events, the ComiConnectors project demonstrates both forms of
recomposing simultaneously, through bringing together characterised textiles and electronics into particular animals with sensory attributes, and then chunking again through placing those named particulars into various event constructions to understand their relationships to multiple actors in the future narratives under development. Fabric and textiles are rewritten and sewn into shapes, with assorted digital components integrated and then summarily named and identified as various animal types they resemble, such as rabbits, cats, owls and dogs. In the second session, the animals are characterised as friends and pets, and even further, by identifying them with proper names such as Scottish Terrier (L40), Professor Owl (L113) and in the third session as Carmen (L1), the one the kids who have been engaged in user testing and feedback would seem to prefer. The specific actions associated with the various electronic creatures may involve specific activities including audio recording, photography and emulated heartbeats in vibration, but CT outlines her attempt, and questions, about consolidating many of these activities into the broader activity of play:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>119</td>
<td>CT</td>
<td>Yeah, but I am also…. But the thing is for kids, will kids play with something this dark?</td>
</tr>
<tr>
<td>120</td>
<td>CT</td>
<td>They will like something like brighter but even this one this kind of more mature colour.</td>
</tr>
</tbody>
</table>

Recomposing is also evident in ComiConnectors project following a discussion about aesthetic preferences, and a challenge she has identified between her own personal preferences and those of the parents and kids she’s been interviewing and testing with. She outlines a particular sound one of the doll characters is able to make, which she highlights as preferable to the one that the kids prefer:
In attempting to consider the preferences of the small sample of children and their parents that she has engaged with has led to the need to make a decision about particular determinate object properties that need to align with the general determinable attributes of the character concepts as representations. A segment of conversation in the topic outlines a further chunking taking place during discussions with another tutor in a separate, offline session, where individual preferences are considered against collective preferences:

In all three cases, recomposing is evident in the moving from smaller units of analysis into bigger ones, and in doing so, also in moving from specific conditions into more abstracted ones. This is seen in the clustering materials and their respective properties being identified and named, with particular actions during sets of interactions between objects and particular users being clustered into events, and even specific users, being clustered into large collective units. Within our framework there are seen in the story grammar approach in our term rewrite...
system through inverting the order to terms. If decomposing is outlined in reductionist terms, as seen in Figure 36, chunking is summarised in the story grammar notation outlined below in Figure 37, using expressions from Franzosi’s QNA (2010, 2004) as applied to our three cases under examination, respectively.

![Diagram of story grammar notation](image)

Figure 37: Recomposing examples from Grasshopper Skateboards, Rapid Prosthetics and ComiConnectors projects

8.2.5 Cohering

Recall our quote from Chomsky at the outset of Chapter 7, highlighting a particular challenge associated with transformational grammars, where sentences can be rewritten correctly according to syntactical order, but are understood as nonsensical. Following our discussion of rewriting, the same warning applies whereby it is not as straightforward a practice as simply replacing one object for another in the upward movement to the event frame — sense must be made as a result of the constructions involving syntax and grammar rules. For instance, it is entirely plausible that a skateboard deck might be constructed from extant artifacts such as eggs, flour, water and sugar, if the anticipated abstract object is understood to be a cake, as opposed to a piece of performance sporting equipment. In this regard, rewriting requires some sort of validity, seen through coherence, in order for it to successfully occur.
Cohering, or the act of making coherence, is the final production rule discussed as part of our narrative design framework. It is defined in the Oxford Online Dictionary as:

_The action or fact of cleaving or sticking together; cohesion_\(^1\)

The process differs from our approach to chunking in the subtlest of manners, whereby chunking puts things together, but coherence allows them to stick together, often understood in conjunction with the connection being logical and sensical. Chomsky’s example, again, is easily composed through grammatical rules, but it lacks coherence and doesn’t stick together. Coherence moves us away from structures towards meaning.

Coherence is an important and well-studied aspect of language and communication, both from the perspective of the structure of a message or narrative as well as its construction (Riessman, 2008). It can be understood both as an attribute of the text itself (a coherent text), as a cognitive state involving sense and understanding (coherence), and as a social process between interactive agents (cohering), such as in conversation. Hobbs & Agar (1985) outline three forms of coherence: local, global and thematic, with an emphasis that it is the pursuit of coherence, often through apparent incoherence, that is relevant to the social realm of talk. Linde (1993) outlines that coherence resides within the text itself, involving a relational process between the narrator, an evolving life narrative, and their coherence system which corresponds to their assumptions about the wider world in which the narrative unfolds. Coherence, as a concept, has not received a lot of attention within the design research community, only recently with Adams et al. (2018) proposing coherence as an extension of Bucciarelli’s framing design as a social process involving negotiation (Bucciarelli, 1994), where coherence allows for the inclusion of a localised form of validation following negotiation:

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Engineers designing, then, are faced with the task of frequently bringing the results of their object world efforts, which no doubt will conflict, into coherence if design is to proceed – and they must do this without a shared proper language. Yet, as noted, they do succeed, at least some of the time (Bucciarelli, 2002).

Coherence in the context of our framework adopts Bruner’s perspective where narrative seeks verisimilitude (Bruner, 1991), or an agreement of the appearance of truth either at a local or global level. In that sense, the framework embraces coherence as a relational process, rather than a definitive outcome.

Coherence is difficult to identify within text, of any type, since it isn’t clear how it actually occurs, or to what extent (Hobbs and Agar, 1985). A set of events recomposed together may initially seem incoherent until they eventually come together with the introduction of key segment which ties everything together, allowing the narrative to suddenly “make sense”. Likewise, a set of utterances may lead a listener to piece together a sequence of individually coherent events which eventually come together but have no global coherence. For our purposes, based on an approach to verisimilitude, responses which highlight agreement or disagreement on the part of the listener start to provide us some clue to the presence/absence of understanding of narrative coherence, situated primarily on the assumption that the pursuit of coherence is a maxim of cooperation between those engaged in textual construction and exchange (Grice, 1989).

In BL2, we see coherence in action early on, notably in responses from the tutor based on the discussions and prototype interactions. Many of these responses come in the form of questions:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>BL</td>
<td>That is one I made myself.</td>
</tr>
<tr>
<td>22</td>
<td>TTR</td>
<td>From bamboo and...?</td>
</tr>
<tr>
<td>23</td>
<td>BL</td>
<td>Bamboo and with maple.</td>
</tr>
</tbody>
</table>
In these segments, the tutor seems to encourage BL with probing questions, to move beyond simple declarations being made to more fuller explanations, requesting an understanding of the sequence of events which have led to this declaration. Moving from the decomposition of the existing skateboard construction into constituent materials, followed by a substitution and transposition of alternative materials, and then recomposing of materials into new objects (eventually into new events) involves the tutor seeking clarification in order to understand whether these moves being made by the student provide a coherent personal project narrative. As presented earlier in Chapter 6 in our analysis of rewriting rules, the tutor examines the prototypical construction presented and determines that what he expects to see is, in fact, not what is presented.

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>BL</td>
<td>I think bamboo is stronger.</td>
</tr>
<tr>
<td>34</td>
<td>TTR</td>
<td>How do you know?</td>
</tr>
<tr>
<td>35</td>
<td>BL</td>
<td>Stood on it.</td>
</tr>
<tr>
<td>36</td>
<td>TTR</td>
<td>Huh? (Laughter) Stood on it? (Laughter)</td>
</tr>
<tr>
<td>37</td>
<td>BL</td>
<td>I have to test it like, you know, properly.</td>
</tr>
<tr>
<td>38</td>
<td>TTR</td>
<td>Okay.</td>
</tr>
</tbody>
</table>

The strategy employed by the tutor in the skateboard tutorial, of asking questions seeking elaborations on the part of the student, is also evident in the second tutorial of the Rapid Prosthetics project. In the early phase of the tutorial, RC outlines his meeting and presentation
of his extant artifact, the prototype, to his client, who has provided him with a number of requests and adjustments for change. The process is set in motion with an early question by the tutor:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>BL</td>
<td>I think... it says it goes... it says it dries after two hours.</td>
</tr>
<tr>
<td>8</td>
<td>BL</td>
<td>It goes tacky after two hours and then it... touch dry after three hours and it is...</td>
</tr>
<tr>
<td>9</td>
<td>TTR</td>
<td>So there is a mixture of...</td>
</tr>
<tr>
<td>10</td>
<td>BL</td>
<td>It says almost a week.</td>
</tr>
<tr>
<td>11</td>
<td>TTR</td>
<td>That makes sense.</td>
</tr>
<tr>
<td>12</td>
<td>TTR</td>
<td>Okay.</td>
</tr>
<tr>
<td>13</td>
<td>BL</td>
<td>Yeah.</td>
</tr>
</tbody>
</table>

A lack of coherence is evident in the concluding statement regarding the scale of the prototype presented as it is reintroduced back into an event frame involving CM as a subject engaged in some action with the new device. As this recomposition takes place, the difference between the extant artifact generated and presented, and the abstracted object which is associated with the abstraction from memory of the reference object that RC “seems to remember” and L13. The discussion unfolds as RC outlines the rest of the oppositional differences uncovered in the recomposition of the object into the user-testing event frame, and a number of features requested which seem to not have been addressed in development. The tutor asks a direct question at L66:

<table>
<thead>
<tr>
<th>Line</th>
<th>Speaker</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td>TTR</td>
<td>And when are you going to Napier to test this?</td>
</tr>
<tr>
<td>67</td>
<td>BL</td>
<td>Oh that is pretty much... Yeah.</td>
</tr>
<tr>
<td>68</td>
<td>TTR</td>
<td>Oh, easy peasy. Yeah. When are you going to Napier to test this?</td>
</tr>
<tr>
<td>69</td>
<td>TTR</td>
<td>Have you talked to PK?</td>
</tr>
<tr>
<td>70</td>
<td>BL</td>
<td>Yeah. I got to ring him about... because I find a...</td>
</tr>
<tr>
<td>71</td>
<td>BL</td>
<td>...one of the way I was planing them down was sticking them to a piece of MDF and putting them through those surface plane but then you got to stick it down with a tape. A double-sided tape. But then the tape sticks...</td>
</tr>
</tbody>
</table>
Here, whilst the object is extant in its presence with the client, it might be suggested local coherence is established in the recognition that this is a concretised manifestation of the abstracted concept within the prosthetics category, but globally, coherence is not yet found in that the object, when returned to the event frame, in its lack of acceptance by the subject CM. RC suggests that the changes required at a global level present him with challenges at the local level, since he remains unclear as to whether these can be rewritten back into the object, when subsequently decomposing his testing event with CM back into the object layer for characterising again (“too big”), rewriting and again checking for coherence, in an iterative approach to developing the prototypical extant artifact which he is struggling to conform to two abstracted object concepts, the one he is thinking of, and the other that his client CM is attempting to articulate to him. Coherence, it seems, is more readily identified in its absence, than its presence, but manifests itself through difference when another narrator is brought into the action and allowed to engage this framework from their personal perspective.

8.2.6 The Other: Multiples

In the previous section on cohering, I outlined discussions primarily involving with strategies involving local coherence, where production rules leads to rewriting, and recomposition, where sense is made by the design student themselves, or in partnership with the studio tutor. Hobbs & Agar (1985), introduced at the start of the previous section, outlined three forms of coherence: local, global and thematic. In the tutorial interaction in the Rapid Prosthetics project discussed in Chapter 7, we outlined the importance of global coherence across multiple narrators, where it was understood that each narrator was engaging a personal approach to the framework, employing a global grammar structure which is employed and facilitates local level construction of meaning through contextualised narrative compositions. In introducing a rewritten object into a recomposed event frame, RC was unable to transfer his local cohering
production results across the framework, where CM suggested the cohering, based on his own approach to production rules in the framework, produced different local results. This important feature of the DDF framework implicates that the framework is not necessarily linear, or successive, but that each stage must be concluded successfully both locally and globally, and if not done so, will engage additional cycles of decomposition, returning to the appropriate layer for characterising, in an attempt to rewrite once again in an attempt to eventually achieve coherence, through concealing difference.

8.3 Discussion: Difference and design

This concluding section of Chapter 8 opens the discussion regarding the proposed framework as involving narrative thinking. The position is in part aligned to the works of Polkinghorne (1988) and Bruner (1986, 1991). Bruner was mentioned earlier, in our discussion of coherence and the need for verisimilitude, and it is worth a more thorough introduction to Bruner’s thinking, in order to explain both what verisimilitude means specifically, but how it contributes to narrative thinking and knowing through difference, more generally.

8.3.1 A framework of action events, past and future

Narrative, others have argued, is about the action (Labov, 1972, Bruner, 1991, Riessman, 2008). Kress suggested that narrative, as one form of text, comes about because of difference (Kress, 1989a, Kress, 2010). Our opening move from chapter 1 composed these conceptual units together, placing them inside the project (the place of projection) and added reflection as an extension of narrative thinking, resulting in emergence of difference through the generation of various texts, in the broadest sense. The Design Difference Framework was presented and discussed based on our empirical observations and analysis, leading to the construction of accounting for design practice in the narrative mode, as an approach to difference in both
revealing it and concealing it. In short, what stands here is a framework predicated on design and its relationship to materially oriented action (Halliday and Matthiessen, 2014). But a few challenges remain, and these are discussed below.

The DDF, as an action framework, has done a useful job in highlighting the complexities of a reductionist approach to the topic of design, but making apparent through a narrative presentation of discourse in design studio tutorials that difference is persistently involved in making action necessary. The richness of the studio, I suggest, which has been put to one side to focus on the discourse, significantly amplifies the difference in the product design project. Focussing attention on the narrative transitions through discourse has made, I believe, the role of difference, as something to be reflected upon, somewhat clarified and simplified in our framework approach, employing a familiar and accessible grammar structure to provide examples supporting the framework development.

The heart of the framework is the production rule, with rewriting rules being a specialised instance of production leading not to reduction but reconfiguration. The framework has been created based on particular examples found in our studio tutorial case studies involving the development of prototypes, as part of the narrative, and the manner in which they are accounted for in their rewriting and subsequent recomposition back into the event frame. An unfortunate artifact is revealed in our framework through the use of production rules, which requires a brief explanation, and its relationship to difference and Deleuze’s contention that events are spaces which allow things “to become” (Deleuze, 2014).

The production rules such as rewriting are simply forms of action themselves, and when enacted, effectively making them sites of the event, if we follow the logic embedded in our framework. Given there are 5 production rules involved, and if we recompose these 5 events into one collective unit, according our framework we are effectively involved in the
construction of a narrative. But this becomes immediately self-referential, and possibly problematic. Is the immaterial event, and by association difference, a thing that can be seen, found and determined? If so, how do we encapsulate it, what are its boundaries and properties? Here, I suggest, we have trapped ourselves within the design difference framework itself, which reveals a particular production rule which has not yet been discussed, involving objectification.

Objectifying the event involves a production rule that turns from a determinable concept about action into a determined, but immaterial artifact, allowing for it to then be engaged through the production rules of characterising, rewriting and revealing difference in events as types of things. This is not a theoretical artifact, but actually occurring in the tutorials, but unaccounted for in our framework’s attempt to characterise particular actions as production, rewriting them and naming that into one of our 4 listed types, and thereby concealing difference in the process.

Deleuze offers a possible way out, in suggesting that the event, predicated as a “site of action” is itself the action, and the naming and identification an event is merely to conceal some form of difference, through objectifying it, allowing it to be characterised, named and compared to other objectified events. This process, if conducted in reverse, allows us to see the objectified things in our framework, such as the project — and consider that, as an object, it can only be so because it has been composed as such, and when it is itself considered an action, the project as object returns to action oriented event of projecting, casting forward experiences which have not yet been had, in contrast to the narrativising of past experiences found in the objectified narrative event.

In summary, whilst we have been invariably looking for actions, we have become seduced by the actions of searching, and in the process, objectifying in order to reveal or focus on particular characteristics of objectified things, so that they can be rewritten, making new difference apparent in the process of trying to conceal previous difference. This circuitous and metaphysic
conundrum situated in our framework has not been properly addressed, and will require further work and examination in order to escape the spiral of self-reference.
Unlike the constructions generated by logical and scientific procedures that can be weeded out by falsification, narrative constructions can only achieve "verisimilitude." Narratives, then, are a version of reality whose acceptability is governed by convention and "narrative necessity" rather than by empirical verification and logical requiredness, although ironically we have no compunction about calling stories true or false.

(Bruner, 1991)
9.1 Introduction

This final chapter of the dissertation allows me to return to my original research question and critically reflect upon the work undertaken over the course of the PhD study, to draw some conclusions from the process and outline what I believe are useful and important contributions to new knowledge relevant to my discipline, and finally, to consider future and further research opportunities as a result. These three components are each addressed in the pursuant 4 sections which make up this overall concluding chapter. In acknowledging Bruner’s perspective in the opening quotation of this chapter, I contend that I am not seeking hard logical truths, but enough verisimilitude to ensure that the thesis generated through this dissertation provides enough validity in its narrative account, in lieu of hard facts providing verifiability.

The structure of the chapter is outlined below.

In Section 2, I return to my original research question and critically reflect upon to what extent I’ve addressed that question, taking into account the entanglements between the associated four thematics regarding design projects (in lieu of problems), narrative transitions, reflection and difference. I discuss, my insights generated through the study, as well as providing some explanation to the factors which have presented challenges, from which I’ve learned, but during the course of the dissertation project have prevented a more robust research project addressing my intended line of inquiry.

In Section 3, I reflect upon what I understand are contributions to knowledge I have made by undertaking the examination of my thesis, and the ways I believe this has contributed insights to my field, particularly in theory and method, relevant to design pedagogy and education. I also consider and discuss aspects of knowledge transfer, outlining the extent to which the
design difference framework can be implemented to help extend knowledge, theory and practice, particularly in the educational context.

In Section 4 I critically reflect upon outstanding questions which remain, new questions that have emerged and opportunities which may be pursued in future work as a result of the undertaking of this thesis project. In particular, I reflect upon the nature of difference (a concept frequently introduced through this dissertation), and a potential relationship to a design practice that may warrant further and deeper examination, through future research work.

The final section of this chapter, the coda, concludes the dissertation with a personal reflection on my personal journey, what I have learned, and the value of having undertaken a part-time research degree as a mature professional over the course of the past decade.

9.2 Addressing the research question

At the conclusion of Chapter 2, I presented the thesis research question, generated through 4 key themes examined in the literature review, and these have informed the activities associated with this dissertation. Here, I move forward with discussing the extent to which I’ve been able to address this question, through these themes, based on the decisions taken in the execution of this thesis. Where I’ve not been able to address the question effectively within the project exist, I discuss why.

9.2.1 Answers to the question

The paradigm of design as a social process was discussed in Chapter 2, compared and contrasted with three other prevailing paradigms in Table 3. This perspective, which is the one adopted throughout this thesis, assumes designers to be one among many participants engaged in the process, to be involved in argumentation, negotiation and resolution, to be constructing
rationales to address complex problems rather than generating solutions, and to be adopting critical thinking as the attitude to analysis and learning. I established in the discussion of Chapter 8 that our Design Difference Framework (DDF) corresponds most closely this paradigm concerning design than the other three paradigms presented in Chapter 2.

The question I posed in Section 1.2.1 was:

how can we understand and contend with the richness of design practice encountered in the design studio, particularly in the educational context, through the talk and conversations that takes place in and around it?

Below I provide three points which I believe highlights how this research project, analysis of data and insights generated through my methodological approach has addressed this question above.

With my first point, I believe that the Design Difference Framework highlights the richness of product design when adopting the lens of a story grammar and the associated production rules. The framework, based on term rewrite systems associated with Rewriting Logic, highlights that rules are useful to provide structure, but facilitate flexibility in accommodating semantic ambiguity when engaged in decomposition. Decomposition makes available finer grained detail of the circumstance in moving towards increased specificity and particularisation, revealing difference in its approach to expansiveness, opening up the generic homogenous structure to provide space for an increasing level of heterogeneity. Characterisation, the second production rule in the DDF framework allows for the conversational exchange to focus on increasingly particular properties in the extant, determined artifacts as they are being compared and contrasted to highlighted attributes of the abstract, determinable concept, which is eventually recomposed into the event, then narrative frame.

With my second point, I outlined in my analysis that rewriting through semiotic rules has complex consequences, namely involved with ascertaining difference between concept and
object after one of the production rules has been applied. However, rewriting has different consequences whether applied to abstract concepts or to extant objects. Rewriting concepts was not witnessed in our tutorial sessions; rather, what was witnessed exclusively was material modifications of extant objects, which seem to retain concept category membership albeit with caveats of different types and instances of members within the category. What this implies is that there may be two outcomes involved with rewriting; one being material modification, the second being conceptual enhancement and expansion. As extant skateboard objects are physically modified with new material substitutions, leading to the presence of multiple instances coming into the frame of examination (bamboo and maple skateboards), the concept of skateboard was not altered, only expanded to include both material versions.

Characterisation and rewriting were discussed extensively in Chapter 6 in the initial tutorial interaction in the Grasshopper Skateboards project, where decomposition to object and material levels highlighted the role that properties and attributes play in determining object and concept determinations. The skateboard is characterised by the adjective wood (not plastic) providing a particular focus on woods as subjective materials, where different woods are compared and contrasted against a variety of properties and attributes such as strength, flexibility and durability. A characterisation of a plastic skateboard, for instance, would have created a new set of properties to be brought into the frame, including new sets of rewrite rules corresponding to technical processes which enable those properties to be managed, changed and altered during development. Despite the fact that a plastic skateboard is not discussed in our tutorials, it does not imply that plastic skateboards do not exist (they do), but only that the practices of decomposition and characterisation have led us to particular materials relevant to the contexts implied in other upwards event layers, so that other potential options do not need to be discussed.
My third point regarding my ability to address the research question — learning about the richness in the design studio — flows from my examination of discourse, and highlights the perspective that the path from decomposition through to recomposition can highlight difference at any turn. The DDF framework has outlined a set of production rules starting with decomposing the narrative through a series of steps into object constituents and in many of the tutorials even further into materials. The presentation of the framework implies a relationship between particular determinate things, named as events, subjects, actions, materials, properties, etc. This was derived from our adaptation and application of the story grammar highlighted in QNA method developed by Franzosi (2004, 2010). At the heart of narrative is the action in the sequence of events — something happened (Labov, 1972). While the DDF framework in this sense seems benign enough, it should now become apparent that difference emerges between decomposing as a reported action, and the act of decomposing in the moment. The production rules we’ve outlined in the framework are themselves actions (decomposing, characterising, etc), things the designer as narrator is doing in the space, in identifying events. But that suggest that these actions can also be described as events themselves, according to the framework. Decomposing is an event, rewriting is an event, ad infinitum, suggesting perhaps (inconveniently) that there is nothing more to the framework than acts of “eventing”. The way out of this metaphysical conundrum is to outline that “eventing” requires the narrator to identify and select the particular events which are being strung together in order to tell the particular narrative to convey meaning, and this involves addressing time and space, where the designer as student is able to “step back” from the current action in which they are engaged and “look back” to recount the events they’ve engaged in the framework, decompose, characterise and summarily also rewrite them. This highlights the important recognition that the there are multiple story events taking place simultaneously, which are applicable to scrutiny in the framework leading to assorted narratives in construction. At a basic level, two narratives are
being transitioned in the tutorials, through two distinct projects underway. While the student is busily engaged in their material project designing a skateboard, the tutor is busily engaged implicitly helping the students to tell their project story, understood as his pedagogical project of ‘designing the designer’. Inevitably, the student discusses both projects at the end of the academic session, where they will present their project outputs, outlining that they’ve arrived at this outcomes through their learning regarding what it means to engage a project in an appropriately designerly way.

9.2.2 Challenges and outstanding issues

Having outlined above that the Design Difference Framework has successfully addressed a number of aspects around the research question from Section 1.2.1, the examination of the themes through the research question might also be challenged based on some observations made through the study which may suggest that some thought, and more work, may still be required. Below, I discuss three particular challenges I’ve identified which might have been addressed in alternative ways over the course of the dissertation project in order to strengthen this research.

The first challenge within the dissertation involves the emphasis placed exclusively on the studio interactions under examination. These conversations in the studio are localised tutorials involving the tutor and the student and their perception and understanding of events taking place between their sessions. Coherence and recomposing take place in this liminal space as the tutorial participants conceptually recompose materials into objects, objects into events and events back into narratives. Local and global coherence was discussed in Chapter 8, whereby local coherence was outlined as agreement between parties in the conversational frame, and global coherence as an aspect of overall project structure, outcomes and consensus with others. Within the tutorials, these other subjects and actors are named and identified, as they’ve been
engaged in separate conversations, between the tutorials we are examining. Whilst the tutor is meeting students at regular intervals, students are engaged in a variety of other local conversations between those intervals, meeting and talking with workshop participants, project clients, other tutors, technicians, and classmates, to name a few. These conversations are outlined, raised and often interrogated in the intermediate tutorial conversations, implicating particular aspects of these out-of-frame local dialogues becoming more global dialogues as they begin to affect the project scope and direction, as the student requires to construct more global coherence through taking into consideration how others view and understand the project development and progression.

This was emphasised particularly in Chapter 7 in the 2nd tutorial session in Rapid Prosthetics, where out-of-frame interactions between RC and CM have been brought to bear inside the intermediary tutorial space, requiring more local production as a result of witnessing the decomposition, characterising and rewriting done by others, not in the tutorial. This, I argue, is not an artifact of poor or mistaken design decisions coming to light, but an active process encouraged by the tutor across all interactions with all students, encouraging them to speak, share and work with others to find ways to recompose sets of local discourses and coherences into more global, project level ones. The role of “other narrators” contributing local perspectives to the global “prototype story” is outlined and formalised into the DDF Framework when considering that multiple approaches to the framework are taking place concurrently, but with different outcomes as a result of experiences in engaging with rules of production.

As a result, because past interactive engagements with others are being examined in our conversations between the tutor and the student, an implication may have been made that the predominant mode of discourse within these tutorials is narrative in form, in lieu of other forms of discursive activity including description, exposition or justification. It is clear that the
transcripts are full of descriptions of things which are involved in the tutorial, and these descriptions are sometimes justifications in disguise, with students presenting work for approval in demonstrating that they are doing things correctly and appropriately. The dynamics of power within the tutorial session also allows for the potential of narratives being fabricated, assembled by the student for the benefit of the tutor to illustrate that they can be evaluated positively and considered to be engaged in design practice appropriately. Where this was a clearly evident problem, the case studies were not employed, further reducing a useful sample of materials in order to draw useful insights for analysis.

The second challenge to the thesis is the nature of the data collected in the process of operating as an insider-researcher, as outlined Chapter 3 on Methodology. An early ambition in the research process was to attempt to access data that was as situationally authentic as possible. The position adopted was an attempt to avoid experimental approaches to design practice, by situating myself as close to the actual, empirical practice as was possible. However, this has resulted in messy data being captured for analysis, proving at times difficult to analyse and reconcile. A full semester of audio recordings were attempted during the data collection phase, and much of this work was unsuccessful, resulting in inaudible audio recordings that lacked any point of reference. Those recordings that were most successful were 1:1 interactions, but even those presented challenges in that conversation is often broken, internally referential and replete with deictic references (this, that, those, these, there, etc) which are very difficult to process through audio and transcription alone. At times, during recording, my role as a researcher would have to be suspended in order to teach, to actually guide students and steer their projects for them, inadvertently imposing myself into the data, despite my best intentions to not do this. However, I believe that where the methods worked, they worked rather well, but resulted in a small sample size, restricting the data set and prohibiting broader analysis than had been originally hoped for.
The third challenge within the dissertation itself is the lack of verification and validation of the Design Difference Framework. The framework has not been tested nor tried with others, and remains exclusively in the realm of theory at this point. A critical question is “how to validate?”. This may involve the production of some concretised material, whether for teaching or research, enabling an audience to work through the framework and provide experiential insights to help shape the framework further. The Validation Square Framework by Pedersen et al. (2000) has been discussed as possible mechanism to provide validation, but it will require assessing the performance of the framework in practice, not only in theory. This is work that is yet to be done.

9.3 Contributions to new knowledge

Reflecting on the research scope outlined in Chapter 3, taking into consideration again Eckert & Stacey’s Spiral of Applied Research (2003), I suggest my thesis is contributing to knowledge of a theoretical nature for the design research community, drawing from empirical studies situated in design education. The main contribution within the thesis is towards a more nuanced understanding of design studio pedagogy, and the nature of student-tutor interactions, embedded in student design projects, which fosters critical reflective activity in students regarding their own project directions, outcomes and reports, seen through associated narratives of transition as an additional project outcome.

In the early stages of the dissertation, position papers and posters based on preliminary insights on theoretical perspectives regarding design thinking and communication were presented to the design research community at a selection of events including:

- IASDR 2013 (Tokyo, Japan);
- Kansei Engineering and Emotion Research (KEER) Conference 2014 (Linköping, Sweden);
Design Cognition and Computing (DCC) Conference 2014 (London, UK); and
- Objects in Design 2014 Symposium (Open University, UK).

These papers, posters and presentations were an opportunity to discuss phases or aspects of the emerging research project in this dissertation to the wider design research community, but did not lead to publication. The work presented at these venues involved preliminary insights regarding a theoretical basis about the relationships between talking about objects and the perception of objects during the discursive sessions in the design tutorial, drawn from and contributing to further thinking about work undertaken primarily in Chapters 5 and 6 of the dissertation.

9.4 Reflecting on future work

Having completed the dissertation, an important consideration is to reflect back and consider what contributions have been made which give back to the field, it is equally important to reflect on potential for future work and new experiences on which others can build. In contrast to the small number of impactful contributions made so far, I am able to see at the conclusion of this dissertation project three concrete priorities for near-future work to be developed as a result of undertaking this research project, and a longer term project associated with continued contributions to design research and theory, further examining the relationship between difference and design.

9.4.1 Three priorities

For the near future, my first priority is the concretisation of the Design Difference Framework presented in Chapter 8 and its application to design pedagogy as a toolkit to foster a narrative perspective on design for experiences. This work is already underway in the development of course materials for my own teaching programme in Edinburgh, which is adopting a
perspective to design projects in the postgraduate studio predicated on scenario planning and
design development employing the story grammar framing. The development of more formal
course materials is anticipated to facilitate the opportunity for respondent feedback, allowing
for analysis, improvement and validation, outlined in the earlier sections as one of the
challenges that this dissertation has been unable to address.

My second priority for near-future work is publication. I believe that there are three particular
journal papers that can be extracted from the thesis, eventually contributing to theory and
method development which would be useful for the field. These include:

- A position paper examining the 4 modes of discourse, and mapping their
  prevalence in the design research literature and how each is related to design
  creativity and cognition. The relationship to narrative discourse and design
  thinking has been touched upon throughout the dissertation, most significantly
  in Chapter 2, involving a small survey of literature in design research
  community focussing on narrative and its applications in design practice.
- A paper on surveying contemporary methods of graph theory and
  linkography, and the potential viability to support further linkographic practices
  using more readily available software platforms, whilst still affording the
  richness of the constructed visuals associated with the typical linkographic arc-
  diagramme format. This paper will be derived from the work conducted in
  Chapter 5.
- A theory paper proposing the suitability, applicability and usefulness for
  considerations design thinking, currently discussed as a form of abduction, as a
  term rewrite system adhering to principals of rewriting logic. This paper will
  draw from the work in Chapters 6 and 7, where the adaptation of QNA as an
  approach to examining narrative transitions was discussed.

My third and final priority in relation to near-future work is methodological in scope and
intends to address the challenges associated with data collection of tutorial transcripts in the
studio outlined earlier in this section, through further practical developments leading to better
insights to promote and practice research as an insider (Saidin, 2017, Fleming, 2018) promoting
a better understanding of qualitative research methods useful for product design practitioners.
I suggest the approach requires methodological reflexivity in being able to access difficult fields for observations, and clarification of this method, including approaches to practice relevant to the design domain, will be of value more broadly.

9.4.2 Difference drives design?

The DDF framework, a result of the analysis of interactions between tutors and students engaged in their design projects, based around the 4 themes highlighted in the introduction and interrogated in the literature review, makes extensive reference to the term ‘difference’, what Kress (1992, 1989a) suggests is the driver of text. Difference was discussed in the conclusion in Chapter 8, where the DDF framework was presented, but one question persists. If our examination has been focussed on reflection surrounding various forms of generated texts (objects, drawings and conversations), and difference drives these texts into being, is it possible to extend this premise and suggest that “difference drives design”? In this following segment I reflect upon this subsequent philosophical question, suggesting that it involves significant future work and consideration.

The discussion at the closing of Chapter 8 highlights the complex and often counter-intuitive nature of difference, as a concept. The post-structuralist philosophers warn us that our logical thinking, with an ambition to classify and structure the world into assorted systems may be misleading us, particularly with regards to difference. Where Deleuze outlined the 4 pillars of reasoning that mediate difference (identifying, analogising, resembling, opposing), he suggests that we are doing this reasoning actively — reasoning itself is an action, situated within a “reasoning” event, leading to some outcome (understanding). A project, he might also suggest, involves a series of actions to bring the project into being (projecting) as much as design is an event, a series of actions within events, collectively understood as designing. The event is a central pillar in post-structuralist philosophy (Deleuze, 2014, Badiou and Feltham, 2007) but
not as a determinable extant thing, but as determinate concept that involves actions that bring objects into being: “design moves” are something design researchers can examine only because an event has already taken place, with someone “moving” something, allowing some “thing” to come into being, as a consequence. In that sense, things in the world are waiting to become, less between thought and object (Bucciarelli, 2002) than between thought and action.

Throughout the thesis, difference has been implicitly connected to reflection, with a gentle suggestion that difference is what is being reflected upon. However, reference to any particular type or form of difference is not forthcoming. The majority of theories of reflection discussed in the literature review, (Kolb, 1984, Boud et al., 1985, Mezirow, 1991) place emphasis on reflecting on actions, where Schön’s seminal work (1983) is characterised as reflecting-in-action. Either way, the relationship to action is clear, but what is suggested is that reflection is a process of examining the consequence of actions, where the consequence is either expected, or not. If consequence is expected, there is no difference, since thought and action are aligned. If consequence is unexpected, a doubt, uncertainty or ambiguity emerges, between the expected event and the unexpected outcome. But if, as I have suggested, it is difference that is being reflected upon, what is this difference?

For Deleuze, difference can only involve multiples, allowing for some “between” which reveals a gap, or schism, where difference comes through. In this study, through the DDF framework, the particular gap where difference comes through depends upon the context of correlate constituent parts in the event re-framing (another subject, another object, another time and place); each new rewriting of the event allows other aspects of difference to emerge in new and alternative ways. This is because we are constantly engaged in reframing actions and events which have already taken place (prior situations) which are concealing difference, through our sense-making actions of organising, naming, grouping, categorising and conceptualizing the infinite heterogeneity of the world into ever larger compartments of similar
things, none of which is naturally aligned to the determinate world, but to our understanding of the determinable representations that construct it. These determinate events, precedent artifacts, existing situations which are under examination are one member of a system of multiples, where the determinable prototypes, future scenarios and preferred situations (Simon, 1996) on which designers speculate are being compared, contrasted and assessed.

This gap between multiples, allowing difference to emerge, can be seen in Schön’s case study of Petra and Quist which I outlined in the introduction, where an approach to design practice was outlined as “seeing-moving-seeing” (Schön, 1983, Schön, 1992b, Schön and Wiggins, 1992). Here, a designer “sees” the situation and makes a “move” to change it; and “sees” again to reflect upon the consequence of the move they’ve made. Here, Deleuze’s multiples are readily available in the initial state prior the designer’s move, and the subsequent state following the move. What is reflected upon is the consequence of the move, the difference between the two states, whether it be a recognition that the applied move brings about the intended difference, an unintended difference not desired or required, or an unintended difference that exceeds expectations and generates something desirable, but unexpected. As Schön suggests:

_In these cases, a better description of the move-testing experiments is this: do you like what you get from the action, taking its consequences as a whole? If you do, then the move is affirmed. If you do not, it is negated (Schön, 1983)._ 

But why make a move in the first place? Some “seeing” takes place with respect to the reflecting-in-action triad (see-move-see), itself an action (a type of move) that reveal allows some difference to be revealed whereby the move is either affirmed or negated. If moves are made, the consequences are acceptable and a move is affirmed, no difference exists, or some difference emerges which is unanticipated, exceeds expectations and is preferable. If a consequence is not acceptable, the move is negated, suggesting again that a difference emerges, but one which is not preferred. In this brief outline of Schön’s thesis about reflecting-in-action, difference becomes evident in variety of ways, through both seeing and moving, as actions in an event frame.
Difference is evident through our various comparisons of multiple circumstances, between those ones which we have identified as inadequate, and those we have identified as preferred, or alternatively, between those which have not yet arisen due to our lack of understanding of the consequence our moves may have. Difference is revealed in the schism between our understanding of the world as it is, and our actions associated with allowing another world to become.

And through this, a key question which has been hiding in plain sight emerges, which begins to form an outline of longer-term future work: *Does difference drive design?* This is a difficult question to answer, but I suggest it might, and this is worth further examination. It does so in the intention to decompose, to characterise, rewrite and ultimately cohere disparate things together, suggesting that designers are engaged in processes of revealing and concealing difference, highlighted by gaps between general conditions and particulars. Quantitative measures associated with mathematical difference are deceptive in that they involve static objects in comparison, measured across a particular metric and dimension. Acting to move one of the objects, in any number of ways, reveals difference. Leave things alone, and difference may only become evident in changes in time, as Ashby and the cyberneticians outlined in the introductory quote to Chapter 6. The first law of thermodynamics helps us here, too: things don’t change unless acted upon, somehow involving adding, subtracting, substituting, or permuting things in time and space. The ambition of the designer, engaged in actions of displacements (Buchanan, 1992) contends only with difference, evident throughout the transcripts of tutorial interactions examined. With this question in mind, driven by post-structuralist philosophy, but clearly involving semiotic principles, a longer term project involving difference, reflection, narrative transition and design practice is already in the making.

9.5 Coda
In his seminal examination of the stories of impoverished inner-city communities in New York, William Labov presented a narrative grammar to correspond to the stories, tales and accounts provided to him and his research team about the experience of inner-city life (Labov, 1972). Labov outlines at the outset that the basic structure of narrative in perhaps its simplest form: something happened, so what? The formal grammar he proposed was slightly more elegant — the 6 steps involved were discussed in Chapter 2. The final step in his narrative of experience grammar is called The Coda, which involves some type of summary that suggests to the listener that the narrator has concluded and the narrative exposition complete. In fables, tales and myths, it’s often phrased as “and she lived happily ever after”. But as I opened this chapter, I outlined clearly that I believe this is the beginning, not the end, and in closing provide a few thoughts about the importance of this experience beyond the actions associated with the formal study itself.

9.5.1 Reflections

In this final section of the thesis, the coda, I provide one final discussion outlining the impact this dissertation has had on me, as a designer, a researcher and an educator, and whether having undertaken it I have been able to address the doubt I outlined early in Chapter 1, predicated on the difference between my understanding of design from the various perspective I’ve been able to adopt across the theory/practice divide.

In 2008, when I secured my first full-time academic post with the Edinburgh College of Art (ECA), it was one of 4, small specialist institutions involved in Art and Design teaching and research in Scotland. Being a lecturer in a Design School required a terminal degree in practice, not research, and I had met these qualifications when achieving my Masters Degree in The Netherlands in 2006, as outlined in the opening chapter. But by 2010, it was clear that ECA was facing a monumental change as it prepared to merge with the University of Edinburgh, a
research intensive Russell Group university, just across the street. I understood this to be a great opportunity for a design school, predicated on practice, to establish strong linkages with new peers and colleagues in a variety of academic disciplines to learn more about theory, and theory aligned to practice. But it was very clear through discussions with colleagues that there were very different characterisations available. I felt I needed some better understanding of what these new academic colleagues meant in their characterisations of the field. Given that the required academic qualification for a position in the University sector is a doctoral award, it seemed logical that undertaking doctoral study might address this divide and allow me to learn about research in the way that these new colleagues were approaching the subject.

The dissertation has been 10 years in development, engaged, part-time by distance, on top of a full-time lectureship involving other contractual commitments to research and teaching activities. In the beginning, I believed it might be possible to combine this thesis with other required research work as part of my academic contract. There have been a number of attempts to find ways to consolidate other work I’ve done over this past decade to try and support this thesis through practical projects, site work, and more. Since I’ve started this thesis, I’ve engaged three major research projects funded by UK Research Councils, conducted fieldwork in Sub-Saharan Africa and North America, co-written 4 peer-reviewed chapters with esteemed academic publishers, and provided an exemplary Research Excellence Framework return for my academic employer, as well as being a busy studio programme leader. None of this work has found its way into this thesis, but I do believe that this thesis has managed to find a way into that other work.

Aside from the knowledge I’ve acquired about the subject I’ve undertaken, including the development of a framework, a theoretical position regarding design practice, and some useful methodological contributions to design research, what have I learned about being a researcher? In Deleuze’s terms, what happened during “the becoming” a researcher, engaged in the action,
which helped me to characterise and identify myself as “a researcher?” What is the difference in myself, having undertaken these series of actions, and engaging in these various events?

At the outset of this study, I made a conscious decision to avoid what most colleagues in an Art and Design context do, which is to engage in what is characterised as “practice-led research”. The characterisation is intended to suggest that the construction of an artifact as part of the design process, “the practice”, is an equally valid form of knowledge generation as part of doctoral study. I intentionally did not pursue this approach, seeing that the overwhelming majority of my colleagues in disciplines like engineering, social science, informatics, business, and health did not make this distinction regarding a particularly narrow form of situated research activity and since what I really wanted was to fit into the University community better, I opted to approach my studies in the way which seemed compatible with the community I was hoping to join.

Along the path of this part-time study, where I’m inevitably both in and out of the process at various times, I’ve come to realise that “practice-led” research involves redundancy of terminology: all research involves practice of some kind, some kind of action that leads to some set of events where “something happened” and the narrative of experience then needs to be told. Upon reflecting on the usage of the phrase, particularly if I subject to the Design Difference Framework presented as the main outcome of this thesis, the difference becomes evident, through the addition of the terms “practice-led”, to characterise this approach to research as being different from something else, I presume research which might be contrasted as “theory-led”, “thinking-led”, “epistemologically-driven”, or any other form of paradigmatic substitutions which might be made to generate the opposition to “practice-led”. If I have learned anything through engaging in this postgraduate study, it is that I don’t believe this difference to be helpful. Rather, it is simply a manner to actively delineate between approaches where the delineation is artificial and arbitrary (Gieryn, 1983, Gieryn, 1998), leading to
confusion, and suspicion across disciplinary divides. I am grateful for this realisation, yet I also understand that hard work is required to help others on either side of the divide to come to realise that difference is helpful and needs to be revealed as opposed to concealed through designing barriers, boundaries and restrictive characterisations.

9.5.2 The end

In summary, I believe that there is much good to find in this dissertation, despite, at times, the scrappiness evident in handling of method, data and analysis. I remain positive about the basis of the work undertaken and the relevance it has for the design research community, particularly design pedagogy, and look forward to progressing forward with plans for future work.
Appendix 1

Linkographs
Appendix 1a: Linkograph generated from student-tutorial interaction (Session 2) from Grasshopper Skateboards
Appendix 1b: Linkograph generated from student-tutorial interaction (Session 3) from Grasshopper Skateboards
Appendix 1c: Linkograph generated from student-tutorial interaction (Session 1) from Rapid Prosthesis
Appendix 1d: Linkograph generated from student-tutorial interaction (Session 2) from Rapid Prosthetics
Appendix 1e: Linkograph generated from student-tutorial interaction (Session 1) from ComiConnectors
Appendix 1f: Linkograph generated from student-tutorial interaction (Session 1) from ComiConnectors
Appendix 1g: Linkograph generated from student-tutorial interaction (Session 1) from ComiConnectors
Appendix 2

Network Graphs
Appendix 2a: Network Graph generated from student-tutorial interaction (Session 2) from Grasshopper Skateboards
Appendix 2b: Network Graph generated from student-tutorial interaction (Session 3) from Grasshopper Skateboards
Appendix 2c: Network Graph generated from student-tutorial interaction (Session 2) from Rapid Prosthetics
Appendix 2d: Network Graph generated from student-tutorial interaction (Session 3) from Rapid Prosthetics

<table>
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<td>Episode</td>
<td>2</td>
</tr>
<tr>
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</tr>
<tr>
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</table>

Network Graph
Appendix 2e: Network Graph generated from student-tutorial interaction (Session 1) from ComiConnectors
Appendix 2f: Network Graph generated from student-tutorial interaction (Session 2) from ComiConnectors
Appendix 2g: Network Graph generated from student-tutorial interaction (Session 3) from ComiConnectors


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