Fashioning Space:

Transforming the Use of Textiles and Their Inherent Properties by Integrating Spatial and Garment Design Practices in Space Design and Fabrication

An Interdisciplinary 'Through' Practice Approach

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Abstract

This thesis aims to transform and extend the use of textile as a construction material in spatial design by integrating garment design practice. It builds on current research which explores how—rather than making new materials—material innovation occurs through transforming ways of material handling; by working with materials' inherent properties rather than in opposition to them.

This thesis speculates about the integration of currently separate disciplinary practices as a strategy for transformation and innovation in textile use, and as a way of knowing and producing knowledge. Therefore, it is important to understand how integrating spatial and garment design practices can extend and transform spatial designers' use and understanding of the potential of textiles' and their inherent properties. Furthermore, to consider how integration happens, or can happen, in practice.

To answer these questions required an interdisciplinary approach in and of itself. Research 'through' practice was a crucial mode of inquiry in this design research: it allowed engagement with tacit and practical/experiential knowledge in addition to the imagining and creating of new realities.

The dominant research strategy was an interdisciplinary 'through' practice strategy implementing concepts of reflective practice, experiential learning and designers' ways of knowing into Repko's (2008) interdisciplinary research framework. In a pilot stage, and then in a design project, this strategy encompassed reflexive design, making and learning activities using virtual and physical materials and models.

I intended to reflect on that integration happened in my own reflexive design practice by comparing data generated and collected from my own practice with that collected from other designers' practices. Hence, a case study strategy of the same project, designed by other designers (design students), augmented and reflected upon this research ‘through’ practice. This case was studied through participant observation and follow-up interviews.

By reflecting on resulting interdisciplinary design processes, methods, outcomes and insights, this thesis indicates that achieving integration is not automatic when bringing two disciplinary practices together. Also, that the conditions in which it is achieved are those of being situated in context (e.g. in a design project) and experiential learning (of textile handling) involving interaction with members of the community of practice. Furthermore, experiential learning is shown to be the activating mechanism for achieving integration.

This thesis develops a ‘Fashioning Space’ way of thinking as an extended and transformed understanding and use of textile and its potential in spatial design practice. This work prepares the ground for further research into the rich territory of integrated garment and spatial design practices. Furthermore, this thesis demonstrates how design, as a way of thinking through material, can be positioned within the design research context; and how design, as continual cycles of experiential learning and reflection-in-action, can be a strategy to achieve integration of practices.

key words: interdisciplinarity, design knowledge, research ‘through’ practice, textile, spatial design, garment design.

Lay Summary

My doctoral research emerged from a practical issue I encountered in a previous interdisciplinary postgraduate master course. Having come from a spatial design background, directly engaging with textiles alongside peers from garment design practice backgrounds, my attentiveness to the particularity of textiles as a construction material was stimulated. Building actual textiles-based structures or simulating them digitally was, I found, not a straightforward process. Garment design was a source of a distinct way of thinking about and directing textiles that could have wider applications.

This thesis aims to transform and extend the use of textile as a construction material in spatial design by integrating garment and spatial design practices. It builds on current research about materiality that explores how—rather than making new materials—material innovation occurs through transforming material handling, by working with materials' inherent properties rather than in opposition to them.

The thesis speculates about the integration of currently separate disciplinary practices as a strategy for transformation and innovation in textile use, and as a way of knowing and producing knowledge. It is therefore important for this work to understand how integrating spatial and garment design practices can extend and transform spatial designers' use and understanding of the potential of textiles and their inherent properties. Furthermore, to consider how integration happens, or can happen, in practice.

To answer these questions required an interdisciplinary approach in and of itself. Research *through* practice was a crucial mode of inquiry in this design research: it allowed engagement with tacit and practical/experiential knowledge in addition to the imagining and creating of new realities. I investigated through my own reflexive design practice, as my main research

strategy, and augmented this with the study of other designers' practice through participant observation and follow-up interviews.

The resulting thesis develops 'Fashioning Space' as an extended and transformed use and understanding of textiles and their potential in spatial design practice. It indicates that achieving integration is not automatic when bringing two disciplinary practices together, and that the conditions in which it is achieved are those of being situated in context (e.g. in a design project) and experiential learning (of textiles handling) involving interaction with members of the practice. Furthermore, experiential learning is shown to be the activation mechanism for achieving integration. This work prepares the ground for further research into the rich territory of integrated garment and spatial design practices.

This research will speak to designers and researchers with the following interests: extending approaches to textiles as construction material; integrating differing practices; digital design and fabrication software development concerning design tacit knowledge; and linking design education and research.

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Susan Raji Fallouh

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Chapter 1 Introduction

This chapter introduces the interdisciplinary ‘through’ practice research of this thesis, and specifies my main motivations for addressing textile use in space design and construction in an interdisciplinary context. It identifies related disciplines and special terms used in this thesis; research questions; and limitations in current research in related disciplines and their areas of research. It also highlights the role of integration as a strategy for innovation in textile use and spatial design. This chapter identifies Temporary Soft Interior (TSI) spaces, the focus of this research, as a subset of interior spaces. Moreover, it highlights the interdisciplinary nature of interior architecture, which is the main discipline that this research addresses. Finally, it outlines the methodological framework and research design, and ends with a summary of this thesis’s six chapters.

1.1 Motivations for Addressing Textile Use in Space Design and Construction: Interdisciplinary Context

Motivations for this research were drawn from many strands and streams. This section will highlight these and show how they led to the development of the research questions.

Coming from a spatial design[1] background (specifically, interior architecture), my interest in textiles as a construction material was motivated by recent textile advancements, innovations and new applications, I remain open to utilising their interactive functions in space.

[1] Although, spatial design in architectural design literature refers to interior, architectural, urban and landscape design, specifically in architectural journals (Garcia, 2006a and Garcia, 2009), throughout this thesis, the term ‘spatial design’ refers to architectural and interior design including design for performance spaces—unless referring to specific resources from architecture or interior design/architecture literature which specifically uses architecture, interior design, interior architecture or interiors.

Textile is a versatile material with various applications. Its inherent properties and recent advances in textile sciences and textile applications increasingly demonstrate textile's great potential to facilitate and shape our current existence, future and survival.

For instance, an intensive amount of advanced, smart and performing textiles currently exists. According to British materials engineer Michael Ashby (2007), over 160,000 materials (including textiles) are available today for engineers (also architects and designers) to utilise. These were mostly developed over the last 100 years, compared with the end of the nineteenth century, where the number of materials available was estimated as a few hundred (Ashby et al., 2007). This enormous availability of different material choice, or what can be called 'hyper-materialism' (Margolis, 2011), makes material choice very important, particularly with the ever-growing demand for performance, economy and efficiency, alongside the requirement to be more sustainable, to address environmental concerns (Ashby et al., 2007).

This research builds on current research about materiality in spatial design which explores how (rather than making new materials) material innovation occurs through transforming material handling by working with materials' inherent properties, rather than in opposition to them. It builds on studies that recognise the critical role of a spatial designer's understanding of a material's properties, and the cultural and traditional use of materials beyond an architectural context. In this research, I venture spatial design and construction opportunities that benefit from textiles' inherent properties, such as their flexibility/malleability and their ability to fold and drape, by observing their architectural and wider context of use, particularly in garment design.

I use the term 'garment design' in this thesis rather than 'fashion design', as fashion has a much wider scope than the study of garment design and construction central to this research. 'Fashion' refers to garment appearance and style as well as construction, and its study implies a broader context from production to consumption, and systems of meaning and signification (Rocamora and Smelik, 2015) such as social status or individualism (see Chapter 2, Subsection 2.4.1). It is also necessary here to clarify that within the context of spatial and garment design, the term *textile* is used in this thesis to broadly describe woven and knitted fabrics, and also non-woven membranes, meshes, groups of fibres, smart textiles and other hybrids.

I used the term *fashioning* in my thesis title *Fashioning Space*, which is driven from the verb *fashion* rather than other terms that express building and making in order to refer to garment design practice and the involvement of hands to manipulate and direct textile materials, since the verb *fashion* means, according to the Oxford English Dictionary (Seventh Edition) “to make or shape something, especially with your hands”.

This research emerged from a practical issue I encountered in an interdisciplinary postgraduate masters course. As a spatial designer, direct engagement with textiles in this interdisciplinary course, along with peers from the adjacent garment design practice, stimulated my attentiveness to the particularity of textiles as a construction material. Textiles’ properties and behaviour (as a building material) contrasts with the use of solid and orthogonal materials, such as wood and brick, with which spatial designers (including myself) are most familiar. Building actual textile-based structures or simulating them digitally is not a straightforward process; I saw garment design as a new source of a distinct way of thinking in directing textile.

Textiles are one option among an abundance of choices of rigid materials used predominantly in spatial design. Spatial designers follow their own approach when constructing with textiles; they are not trained in the skills of tailoring. Conversely, garment design has a long history of accumulated knowledge, understanding and expertise in constructing three-dimensional forms (garments) using textiles (their main choice of material). Based on these initial observations, I anticipated that implementing/transferring elements/methods/ expertise from garment design and its approach to use and direct unstable two-dimensional textiles to generate three-dimensional garments can transform and inform the way textiles and their inherent properties are understood and used in spatial design, and lead to new space design solutions and outcomes.

1.2 The Research Aim and Questions

This research aim is to re-address, extend and transform the way textiles and their inherent properties can be used and understood in spatial design and fabrication.

This research devises an integration of practice between spatial and garment design as a strategy and stimulus to inform and transform spatial designers' understanding of the potential of textiles and their inherent properties. The shared use of textiles as a material to design and construct space or a garment provides an interface for this integration. Therefore, it also aims to achieve interdisciplinary integration of practice, to understand and interpret this process, and externalise it.

Investigating interdisciplinary practice implied an in-depth understanding of how an interdisciplinary research framework may apply in the context of research 'through' practice, which involves various types of knowledge; notably, experiential/practical and tacit knowledge.

This research focus evolved from focusing on 'what' (outcomes of space design and method 'transference') to 'how' integration of practice occurs and may transform current spatial design practices. It also examines what initiates and/or advances integration.

Therefore, the research questions evolved to ask:

Question 1: How may integrating spatial and garment design practices transform spatial designers' use and understanding of the potential of textiles and their inherent properties in space design and fabrication?

Question 2: If integration occurs, how can it happen 'through' practice?

The process of this research demonstrates how spatial designers, including myself, can develop an interdisciplinary insight into design practice and textile use as a building material; reflected in transformed design practice, new methods and a reshaped understanding of the potential of textiles and their inherent properties in spatial design applications.

By the development of 'Fashioning Space' as an interdisciplinary way of thinking through design and textiles, and as a research design, this research aspired to contribute to the discussion and development of a strategy to support spatial designers to undertake an interdisciplinary journey from disciplinary to interdisciplinary design research and practice through material (textiles). Furthermore, to raise their awareness of disciplinary practices, assumptions, traditions, and methods.

1.3 Current Research Limitations in Related Disciplines and Areas of Research

The literature of different disciplines and areas related to this research revealed a paucity of previous and current related studies research in the following areas. This will be discussed fully in Chapter 2.

1.3.1 Fashion and Architecture Parallels and Convergences

Over the last four decades, the study of parallels between Architecture, Interiors and Fashion has gained interest. Nevertheless, studying the integration of practice on an interdisciplinary level, rather than on a multidisciplinary level, and 'through' practice is still emerging.

The contextual review, Chapter 2, Subsection 2.5.2, shows that research and practice across the borders of spatial and garment design accommodate three emerging engagements: through theoretical literature; terminological borrowing; and the reciprocal inspiration of forms. A limited number of projects/studies focus on transferring tailoring techniques to architectural design, e.g. into computational design of tensile structures (Simmonds, Self and Bosia, 2006), or as an intermedial material for concrete formwork (Milne, Pedreschi and Richardson, 2018; West, 2016), or also to challenge orthogonal typologies traditionally associated with spatial design by exploring new design methodology (Layden, 2014). However, these engagements focus on the outcomes of interdisciplinary research, rather than studying the integration process or reflecting on its interdisciplinary nature. Furthermore, focusing on transforming the use and understanding of textiles as an actual construction material in spatial design is not central.

1.3.2 Textiles and Spatial Design

Reviewing the literature on the practice and research of textile-based spatial design (see Chapter 2, Subsection 2.3.3) highlights three main categories. First, those that draw on tensile architecture principles; second, the use of textiles as a wrapping material over a load-bearing skeleton; and, third, as an interior/exterior vertical space definer, such as suspended curtains, partitions or backdrops. Most of these approaches that use textiles in architecture have been concerned with exterior needs, such as environmental factors and forces; for instance, wind, snow and rain. In Interiors, textiles have been used for reasons of comfort, wealth and status, to delineate and control the interior environment.

The literature reviewed indicates limited research relating to innovative textile use in spatial design, which goes beyond the following three directions. Firstly, developing currently established architectural approaches to use textiles in construction via a computational design, such as in tensile architecture (see Chapter 2, Subsection 2.3.3). Secondly, inventing new types of advanced textiles to facilitate interactive functions. Thirdly, examining new applications of textiles and their innovations for different functions in spatial design, such as interactive functions (see Chapter 2, Section 2.2.).

This research aims to change textile use, rather than invent new types. Among these three directions, only the first one is concerned with developing textile use as a construction material; however, it undertakes this from a disciplinary spatial design approach, rather than through integrating this approach with garment design practice.

1.3.3 The Nature of Interdisciplinary Research and the Study of the Integration Process

Interdisciplinarity is inherent in design, art and architecture, and strong evidence of interdisciplinarity is found in practice-led research outputs (Rust et al., 2007). However, interdisciplinary literature such as Repko, Newell and Szostak (2012) observes a lack of education about interdisciplinary processes and how to conduct interdisciplinary research, and a lack of reflection on the meaning of being interdisciplinary.

> At this moment in the history of the Academy, most scholars who would define themselves as interdisciplinary simply “do” interdisciplinarity. They have not taken courses on how to do interdisciplinarity. They may not have ever read an article or book focused on how to do interdisciplinarity. Importantly, they may never have reflected very much on what it means to be interdisciplinary. (p.8)

Furthermore, Barry and Born (2013) indicate a “paucity of empirical studies of how interdisciplinarity unfolds in practice” (p.2). As Wagner et al. (2011) demonstrate, most published literature focuses on outputs of interdisciplinary research, rather than on processes. They relate this to the fact that studying the integration process is more difficult to observe than the results of the process.

In contrast, this research focuses not only on the outcomes of integration; it also focuses on gaining an in-depth understanding of the integration process in a nuanced manner and how this process unfolds ‘through’ practice.

1.3.4 The Interdisciplinary Research Framework in the Context of Research ‘Through’ Creative Practice

Repko (2008) provides an overarching model of how interdisciplinary integration can occur, based on previous interdisciplinary models proposed by other interdisciplinary scholars, such as Julie Thompson Klein and William H. Newell (Repko, 2006). However, typical of current literature on interdisciplinarity, this model is not directed to research ‘through’ creative practice. Design scholars Barnes and Melles (2007) highlight “the literature on interdisciplinarity has less to say about the integration of disciplinary experiential knowledge” (p.5). This can be observed in Repko’s model, which emphasises the use of language to achieve the ‘common ground’—an essential stage to achieve integration—rather than tacit or experiential knowledge, for instance.

Therefore, the importance of this interdisciplinary ‘through’ practice research is that it presents an empirical study of how the interdisciplinary process and integration may be undertaken in the context of research ‘through’ practice between two cognate design disciplines.

1.3.5 Interdisciplinarity in Design Education

Many educators in spatial design (Cys, 2013; Earnshaw, 2016) highlight the need and the importance of interdisciplinarity to enhance design education (See Chapter 3, Section 3.4.1). For instance, Koo (2012, p.2) suggests that “design educators need to embrace design through meaningful collaboration to develop pedagogy that encourages individual disciplines to learn together and move forward through productive collaboration”.

While this research is not about design education, it is intended to assist educational processes. This thesis sparks questions about how interdisciplinarity can be employed as a catalyst for more provocative questions about design education beyond its disciplinary origins within which design departments are located.

For instance, Chapters 4 and 5 show how students developed a deeper understanding of textiles and different design processes, methods and concepts, besides developing a range of interdisciplinary skills, traits and mindsets, such as the courage to explore unfamiliar territories and perspective-taking.

1.4 The Role of Skills ‘Transfer’/Integration and Advances in Textiles in the Development of Textile-Based Structures

As will be discussed in detail in Chapter 2, textile-based structures have been used since the tent was invented. Structures such as tents, found in different geographical locations worldwide, accommodated several individuals belonging to one family on a small scale. However, over time and through the development of construction methods, these structures have grown bigger in scale and have been utilised for different customs, such as to accommodate public social activities (for instance, festival events or commercial circus tents). Other textile-based structures are roofs, such as those similar to the Colosseum in the Roman Empire; bazaar or souk roofs in North Africa and Spain; and stage sceneries in theatres, special events and, more recently, art installations for interior use.

In the history of textile-based architecture, many notable examples of structures were achieved and built as a result of transferring expertise between adjacent disciplines, and either used textiles as a main choice of material or used technology applicable to textiles' use. An example of that would be the transfer of expertise from sails and ship-making, which aided the creation of significant architectural structures such as the Colosseum theatre's velarium, which was made by sailors (Garcia, 2006; Kronenburg, 2015). Another example, transferring expertise from bridge building which aided the building of cable net structures (the precursors of tensile fabric structures). This occured when "architects began to see the potential of tension structures after suspension-bridge construction reached a perfection stage between 1920 and 1930" (Drew, 1996, p.3).

In parallel, revolutionary advancements of textile material have shifted textile use from a secondary role to a construction material. In Chapter 2, I argue that before material developments in the 20th century, breakthroughs largely occurred through transference of skills, such as the transference of sail and maritime skills into construction. After the 20th century, when new materials were available, material developments and skill transference played tandem roles.

A survey of current structures composed of textiles on a medium to small scale for interior use—such as in art installations, theatre, public spaces—shows that the structural principles used in these structures rely heavily on architectural principles and approaches, such as those of tensile fabric architecture, or as a wrapping textile for stiff and rigid structures.

1.5 Temporary Soft Interior (TSI) Space

The literature addressing textile use in spatial design shows that portable and temporary interior spaces that are made from textiles, or what I shall call Temporary Soft Interior (TSI) spaces ,do not yet form a widely recognised subset of Interiors. TSI is the main type of space considered in this research, therefore, I endeavour to highlight and define it. This has the potential to form a base for future research solely dedicated to study TSI spaces.

Reviewing the literature addressing textile use in spatial design, it shows that the majority of research about textile use in Interiors explore its use from the perspective of soft furnishings, such as “carpeting, casements, draperies, upholstery, and wallcoverings” (Jackman et al., 2003, p.1). Likewise, literature and resources of stage and set design and craft may convey a classic use of textiles, such as in curtains and scenery (cyclorama, backdrops, flats, sets, or props). A limited number of published pieces distinguish certain types of textile-based interior spaces based on textile use as a construction material. For instance, Goldsmith (2013) defines the development of tensile fabric interiors as a critical path within tensile fabric architecture, which emerged during the 1980s (see Chapter 2, Subsection 2.3.3).

Conversely, in the discipline of Architecture, structures composed of textiles or textile-like materials have been identified as a specific architectural subset since the late nineteenth-century, e.g. tensile fabric architecture (Castle, 2006; Huntington, 2013; Kronenburg, 2014). Likewise, in Fine Art, such taxonomy is applied to instances of textile use as the main constructive and expressive medium; for instance, in soft sculptures (McDonald, 2008), textile sculpture (Scott, 2003), and textile installations.

TSI spaces are discussed further in Chapter 2, where I present a definition and a characterisation of these type of spaces.

1.6 Methodological Framework and Design in Response to the Research Questions

This section provides a brief illustration of the research design and strategies used/developed in this interdisciplinary ‘through’ practice research across spatial and garment design, to answer the research questions.

As will be more fully discussed in Chapter 3, this research topic, which exceeds the boundaries of one design discipline and its questions, required an interdisciplinary approach that implements research ‘through’ practice as a crucial mode of inquiry. Research ‘through’ practice was required, as it engages various forms of knowledge, namely tacit and practical/experiential knowledge; in addition, it allows imagining and creating new realities.

In this research, the general methodological framework focuses on the *research process,* linking different methods to practice as a way of knowing. In this research, I composed an *interdisciplinary ‘through’ practice* strategy as the main strategy and augmented this with a case study strategy. Many corresponding methods were used in each of these two strategies.

- The dominant research strategy was an interdisciplinary ‘through’ practice strategy, implementing concepts of reflective practice, experiential learning and designers’ ways of knowing into Repko’s (2008) interdisciplinary research framework. In a pilot stage, and then during a design project, this strategy encompassed reflexive design, making and learning activities using virtual and physical materials and models.
- I intended to reflect on the integration that happened in my reflexive design practice by comparing data generated and collected from my practice with that collected from other designers’ practices. Hence, a case study strategy of the same design project, designed by other designers (design students), augmented and reflected upon my research ‘through’ practice. This case was studied through participant observation and follow-up interviews.

Note: working with a group of design students was a pragmatic decision, based on established collaborations and links between two design departments in one location. A further advantage of this choice was maintaining natural settings and authenticity: students employ creative design processes in their design projects. To create a professional group for the duration of the study would have been a barrier to conducting the research (further discussion in Chapter 3, Subsection 3.4.1). Possible ethical issues for research involving students were addressed (see Chapter 3, Subsection 3.4.4.4).

This thesis discusses new ways of producing knowledge associated with interdisciplinarity and focuses on the integration of practice as a way of knowing and of producing new knowledge. Noting that when I started this research, my previous knowledge and expertise were located in the fields of interior architecture, as well as textile innovations and new applications. Developing an adequate level of knowledge in garment design was a requirement to be able to construct an interdisciplinary understanding of concepts and ideas within the fields in question (Repko, 2008). However, in contrast to how disciplinary researchers develop mastery, interdisciplinarians focus on the mission at hand; “comprehending enough of the discipline to decide which of its defining elements bear on the problem most directly” (p.189). Also, in research approaches involving practice, the lack of equal disciplinary levels of specialisation does not equal thoroughness; the value and rigour of this type of research are in “syncretism, not in depth-mining” (Nelson, 2013, p.34) (see Chapter 3, Subsection 3.3.3 for more details).

1.7 Summary of Thesis Chapters

The thesis is organised into six chapters.

1.7.1 Chapter 2

Establishes the context, defines related disciplines and builds a theoretical foundation of the literature, the current use of textiles and recent research. It provides a review of the spectrum of perspectives and angles from which space can be studied and understood, then narrows to explore the defined angle from which this research addresses space. Specifically, 1) recent directions in research and innovative textile use in spatial design; 2) past and current practice (textile use in garment and spatial design); 3) recent relevant disciplinary research, including insights from complementary site visits I undertook to textile-based spaces and interviews with designers at the Edinburgh International Festival and Fringe—another way to obtain important insights about current practice; and 4) research and practice across the borders of spatial and garment design and their emerging engagements.

1.7.2 Chapter 3

Introduces the development of practice-led research alongside research 'through' practice in Art and Design and Architecture, and the knowledge-creation method in interdisciplinary research. It maps how, for this study, a research 'through' practice strategy is implemented within an interdisciplinary research framework; first within a pilot stage, and then throughout a design project for a TSI space. It also illustrates how a case study of the same TSI space design project, undertaken by other designers (design students) augments this research 'through' practice strategy.

1.7.3 Chapter 4

Presents an account of the progress of this research. It describes in detail the process of data generation and collection during the interdisciplinary 'through' practice strategy, which encompasses experiential design, making and learning activities in a pilot stage, then in a design project for a TSI space. In the augmenting case study strategy, the process of data collection is described through participant observation, two follow-up interviews and case study documents.

1.7.4 Chapter 5

Outlines the analytical research framework and related knowledge types produced by the research. It analyses, discusses and communicates this interdisciplinary research's main findings. It recognises different expressions of interdisciplinary understandings achieved in this research and tests them. It discusses the stages at which I analysed and reflected on my practice in the interdisciplinary 'through' practice strategy pathway—as the main research strategy.

1.7.5 Chapter 6

Discusses and concludes with the main findings and outcomes of this research and the study's limitations. I discuss, for instance, implications of this interdisciplinary 'through' practice research on transforming spatial design practice and textile use; development of 'Fashioning Space' as an interdisciplinary way of thinking through design and textiles; exemplifying a model of interdisciplinary 'through' practice research between spatial and garment design, and on design education, with recommendations for further research.

Chapter 2 TSI Spaces and Garments: Different Artefacts, Shared Materials and Parallel Practices

As explained in Chapter 1, TSI spaces do not yet form a specific subset of interiors in the interiors and architecture literature. The authors of these spaces are architects, interior designers and artists. Searching the body of literature and contextual materials that consider textiles as a construction material for TSI spaces means working with resources about architecture and textiles, temporary portable structures, textile interiors (mainly dealing with soft furnishings) and stage crafts. Therefore, the discussion of spatial design and textiles, that follows in this review, needs to draw selectively from a variety of overlapping histories, theories and practices of interiors and architecture.

A case in point is that concerning textile use in garment design and construction. As this chapter will show, the literature addressing fashion (which is broader than the practice of garment design) is vast, but not all relevant to this study. Fashion is more recent than the practice of garment design, and quite a different phenomenon sociologically (or culturally) speaking. Garment construction knowledge has been preserved by a few specialists from inside the field of fashion, such as in the long-standing activities of costume societies in Britain and America (Breward, 2003).

This contextual review discusses current directions of spatial design approaches to materials: particularly, textile materials. It then investigates past and current textile use in a wider context, and draws a mosaic picture of how textiles, as a material group, have been used to construct and shape different artefacts: from buildings and interiors, with a focus on TSI spaces, to garments. The shared use of textiles provides an interface and shared phenomenon between the parallel approaches of spatial and garment design.

2.1 Identifying this Research Space and Related Spaces: Architectural, Interior and TSI Spaces

This research focuses on TSI space from materiality, design and construction perspectives, within the context of space and its theories. Where Chapter 1 introduced the need to identify TSI spaces and how these types of spaces do not form yet form a widely recognised subset of interiors, this chapter will demonstrate how TSI space design is situated between the disciplines of interior architecture, architecture and art. This section firstly reviews space within spatial design, and grounds this study in a reflection on how architectural space can be understood, before narrowing to the defined 'space' that this research addresses.

Space can be interpreted from multiple perspectives: philosophy, architecture, social science, geography and the arts (Collins and Nisbet, 2010). Architectural anthropologist Amerlinck (2001) notes this point when he says that,

> There is no doubt that architecture deals with space and that probably more than any other discipline its practitioners create spaces. Yet space is a concept derived from Euclidean geometry, and it is an ambiguous term that philosophers and physicians have tried to concretise but that needs to be defined and redefined. (Amerlinck, 2001, p.2)

Understandings of space have also evolved through architecture's history. Architecture has predominantly been discussed as tectonic (form) or space—particularly Modern architecture, where space became central to architectural thinking (Carraher, 2018; Frampton,1995; Porter,1997; Rice, 2006; Sparke, 2008; Zevi,1993). More recent thinking, though, visualises interior and exterior space (space and form, respectively) as unity (Frampton,1995; Porter,1997).

In origin, architecture concerns notions of space evolved from Vitruvius: firm, strong and stable (Szacka, 2018). Architectural voices have also been influenced by Newton's static conception of space, by modern physics and by evolving space-time models of the universe (Frampton, 1995; Szacka, 2018). Such models have influenced art and architecture. In one example of such influence, practitioners became preoccupied with a synthesis of spatial abstraction and rationalising spatial form, e.g. in Gropius' works and the teachings of the Bauhaus (Frampton, 1995; Porter,1997).

Recent studies, such as Hillier (2007), demonstrate that instead of regarding space as an independent entity, the most common notions of space tie it to entities that are *not* space. They link it to human behaviour. Hillier explains that 'space' is "transcribed as the 'use of space', the 'perception of space', the 'production of space' or as 'concepts of space'" (2007, p.19). Here, we might consider Lawson's (2001) studies of the perception of space and cognitive space, or Norberg-Schulz's (1971) ideas about space as a lived experience. Hillier argues that, in architecture, space is linked to a reference; 'spatial enclosure' is the most common way of describing and defining space by its physical forms (Hillier, 2007). Examples are Adolf Loos's 'Raumbplan'[2] and Le Corbusier's Free plan (defining space in relationship to its load-bearing structure); Duffie's sheering layers of space (defining space relative to the varying temporality of different elements of space) (Brand, 1994); Ching's definition of space (defining space in relation to focal points in the field) (Ching, 2005).

Hillier also discusses how, in the Social Sciences, notions of space have often been understood via relating spaces to human agency. Consider here 'personal space', 'human territoriality' and also Lefebvre's (1991) 'production of space'. Lefebvre, for instance, highlights that space is an active designer of our social relations, rather than a container to be filled (Coleman, 2015; Lefebvre,1991; Swyngedouw,1992). While global changes such as migration

[2] In the 'Raumplan' the spatial shape follows the load-bearing structure, however, in the Free plan there is a deliberate separation, sometimes even a contrast, between the organisation of the load-bearing structure and the architectural space. (Cruz, 2010)

and displacement continue to affect our conception and perception of spaces, those spaces we produce, in turn, produce us (Collins and Nisbet, 2010). As with others, these insights, originating in different disciplines, have spread and have been influential across multiple disciplinary fields.

In the literature of interiors, space is discussed in architectural, social science, scientific and philosophical terms. Carraher (2018), for instance, observes that a “confusion about what designers ‘produce’ when they make an interior environment continues today” (2018, p.139). Questions still arise about whether design is a physical thing itself, or the experience the design creates, and they consider the intangible nature of the matter in question: “what we mean when we speak of space and design is thus a somewhat nebulous and fluid thing” (Carraher, 2018, p.140).

The interior space literature (from that on domestic interiors to public ones, and mostly written by architects) features several understandings and interpretations of the interior that imply physical *and* experienced notions of space. Sparke et al. (2009) describe the ephemeral nature of interiors as “constantly being modified as life goes on within them” (2009, p.12). Like Sparke et al., who think of interiors in “constant change” (2009, p.12), Scott (2007) presents the interior as a constant alteration, distinguishing working with and within existing buildings as a “significant alternative” to what he calls ‘pure architecture’, “the making of a new building on a cleared site” (Brooker, 2009, p.62). Furthermore, Sparke (2008, p.8) suggests Modern interiors are “the inside location of people’s experiences of, and negotiations with, modern life”. Literature about the interior thus expresses the complexity of space. Sparke et al. (2009) argue that Modern interiors can be understood as “an image, as an assemblage of material objects, or as space” (2009, p.12). They suggest that different understandings of Modern interiors lead to different possible representations of space “through architectural plans, drawings, photographs, ensembles of objects or constructed spaces” (2009, p.12).

Other voices in architecture criticise definitions of architecture, or its essence, that are centred upon a conception of space. Those such as the philosopher Roger Scruton, for instance, highlight other central aspects, arguing that “certain works of architecture would lose their architectural significance” if built using different construction materials (Sauchelli, 2012, p.56). In the same vein, Sauchelli (2012) reminds us that technological evolution has influenced architecture, and knowledge of materials and their use is a necessary skill for architects. Architectural history holds many examples of architects and engineers skilled in the use of particular materials: Fuller and van der Rohe with steel, and Dieste and Khan with brick, are but a few. Sauchelli concludes along these lines that “(non-spatial) function, materials, ornamentation, and so on, cannot all be reduced to spatial values” (2012, p.61) and requests a revised, comprehensive understanding of space “to take into account the complexity of architectural art” (Sauchelli, 2012, p.61).

As outlined above, various insights of space form various disciplines overlaps, where space can be understood as an experience perceived and conceived relative to other tangible and intangible entities. However, space is also about the ‘non-spatial’: the structure, material. This research acknowledges this spectrum of perspectives to study and understand space. However, it works with an understanding of space essentially as much about materiality, structure and construction as spatial experience. It focuses on the role of materials (here, textiles) and the way in which they are handled as important elements in achieving spatial vision. In this material, constructional vein, it focuses on designers’ insights about the potential of textiles as materials, and the implications of this for the practice of envisioning and creating space.

Turning to TSI spaces, introduced in Chapter 1, Section 1.5, we can think of them as being “about the ephemeral creation of an environment that connects people” (Szacka, 2018, p.271). Similar to portable architecture, these environments are temporary and transportable, designed for short-term existence, for multiple geographical locations. Yet, they leave a place in memory (Kronenburg, 2014). Furthermore, they differ from other spaces: in being both real and imagined, they offer visitors a dual presence of the real and fictional, such as in performance spaces. Experience of space is therefore central in TSI spaces, and these are some of the qualities of that experience.

Possibly the most comparable exterior space to TSI spaces would be textile-based architectural pavilions (small-scale outdoor architectural structures). Pavilions, types of lightly constructed buildings (Junyk, 2014; see Chapter 2, Subsection 2.3.3), have been important architectural structures/spaces in architectural practice and recent research (Drew, 2006; Hensel and Cordua, 2015). Such small building pavilion projects offer more opportunities for experimentation and research, and support greater risk-taking. They can avoid situations that seem to be characteristic of large projects, such as a seemingly inescapable focus on economic profits, efficiency and, increasingly, branding (Hensel and Cordua, 2015).

Another comparable type concerns installations made by architects. Observing recent installations by architects shows that they are becoming increasingly important in architectural education, research and practice (Hensel and Cordua, 2015). Bonnemaison and Eisenbach (2009) demonstrate that these projects have emerged as a way of allowing direct experimentation and exploration of architectural ideas with material and social dimensions without the limitation of a client. The function of these spaces departs from utility towards criticism and reflection. Their most comparable spatial arrangement from art is soft sculpture and installation art, which emerged in the last few decades (Bonnemaison and Eisenbach, 2009) and overlaps considerably with architectural installation practice. Examples provided in Chapter 2 (Subsection 2.3.3) will be drawn from architectural pavilions and installations, as well as art installations.

TSI spaces can also be conceived in architectural literature as part of fabric architecture or portable architecture. However, being contained by and residing inside buildings implies that these spaces are interior spaces too. This distinguishes them from exterior pavilions. Additionally, they do not have to withstand exterior environmental impact and forces, which may imply certain restrictions on their design and construction.

TSI spaces can be located mainly in interior design or interior architecture and also architecture. However, it is not possible to limit their study to that of ‘space’ or ‘practice’, or to limit who designs them (the practitioner) to a single discipline. As will be explained below, the design of these spaces is shared between the practices and practitioners of the interlinked disciplines of interior design/architecture, architecture (including textile-architecture and portable architecture), and art, amongst others such as structural engineering.

While it is not the purpose of this thesis to resolve the disputed terms of interior design, or interior architecture as it is called in some countries (Cys, 2013) and in some other literature (Marinic, 2018), the term ‘interior architecture’ is used hereafter to express interior design and interior architecture.

It is worth highlighting here the inherently multidisciplinary nature of interior architecture. It integrates a vast array of elements of architecture and decoration. Although each has their own distinct histories, traditions and practices, interior architecture seeks to reunite these different identities as a whole (Weinthal, 2011). Furthermore, interior architecture relates to architecture, adaptive reuse, installation art and digital fabrication (Marinic, 2018). Interior architecture as a discipline is also multidisciplinary: the modern interior itself, as Sparke et al. (2009) stress, has to be positioned in a multidisciplinary context. They highlight that it is impossible to limit its study to a single discipline. It is linked to architectural representations (plans, axonometrics and photographs); to theatre, the body and the world of fashion (Sparke et al., 2009).

Therefore, a designer of interior spaces, in general, would not necessarily belong to a single discipline or, in some cases, to a discipline at all. This is evident in that “traditional texts included in curricula for interior architecture students have largely portrayed interior architecture history as a history of interior spaces, regardless of the profession of the author” (Cys, 2013, p.63).

Interior architecture is a discipline within which practitioners play a multifaceted role and must gather knowledge from crafts and ornamentation at the small scale to environmental strategies at the global scale (Weinthal, 2010), but also a knowledge of space and construction at an architectural scale (Ching and Binggeli, 2005; Marinic, 2018). This highlights the importance of interior architecture to draw on disciplinary and interdisciplinary knowledge as a constant strategy.

If we wish to study TSI space, it has to be considered as shared territory between architecture, interiors(including performance spaces), and art; its study would encompass the three.

Therefore, to conclude with a definition and characterisation, TSI spaces include stage spaces for performance, installations and exhibition stands. They belong to both the architectural and the interior disciplines/spaces. Although they are lived, experienced spaces, they are also made possible by their function, materials, structure, ornamentation and so on, which cannot be reduced to solely spatial values. TSI spaces can be understood as space inside a space, or a structure inside a structure. They can reside in various and distinctive spaces and sites that already exist, in cities and the countryside, and form a part of the cultural life of its people. For instance, the occupation of various city spaces in the annual Edinburgh International Festival and the Edinburgh Festival Fringe (Edinburgh, Scotland).

TSI spaces are characterised by flexibility and ease of assembly and folding. Therefore, textiles' flexibility/malleability and ability to fold all play a vital role in achieving and maintaining these traits.

Note on flexibility and structural integrity

Sauer (2010) states that temporary constructions require light and flexible materials, and that lightweight constructions reduce fuel costs for transportation to the building site. Garcia (2006a) shows how textile-based projects are appropriate for temporary, transportable and ephemeral structures, as these structures "demand a more fluid, adaptable, interactive, variable, multimedia functional and dynamic architecture" (p.10).

Noting that in the spatial and architectural discourse *flexibility* can mean different things, architectural theory and practice address flexibility on a conceptual and on a practical level—related to material and structure. Kronenburg (2014) specifies that flexible architecture responds to problems associated with varied and frequent changes (ecological, social and economic in nature), and, thus, flexibility is not a new phenomenon in architecture. Flexibility, fluidity and continuity have occurred in spatial design throughout the history of Western architecture and interiors: from "the Baroque, to Art Nouveau, Expressionism, the futuristic Sixties, contemporary Blobs and Folds" (Constantopoulos, 2019, p.101). Also, Kronenburg (2007) states that, on a practical level, flexibility is a feature and requirement of a building, as flexible buildings are proposed to respond to fluctuating conditions in their use, operation or location. Kronenburg (2007) identifies features of flexibility in buildings, such as adaptation, transformation, interaction and movement. Such buildings, Kronenburg (2007) argues, are frequently innovative and expressive of contemporary design issues since they are, by their essence, multi-functional, and cross-disciplinary.

In the same line of thought, an example of one interpretation of flexibility in buildings is the Modernist Free plan. As Zevi (1993, p.142) remarks, the Free plan “re-evokes the Gothic desired for spatial continuity for real structure”. Scott (2007) describes the Modern space as functionally flexible (facilitated by its frame-structure) in comparison to the strictures imposed by the Classical plan (imposed by its load-bearing structure). This highlights the role of structure in facilitating flexibility. However, although some concepts of Modernism, such as the ‘Free plan’ (reference le Corbusier), are considered as an advancement towards functional flexibility, in other aspects many designers felt that mainstream Modernism perceived architecture as a fixed form, and that it was experienced as such.

The British avant-garde architectural group Archigram, for instance, felt uneasy about the mainstream Modernist preservation of ideas once occupied by Classicism. Instead, they proposed change, flexibility, mobility, adaptability and responsive architecture as an antidote (Knippers et al., 2011). They did so in works such as that seen in Figure 2-1 (Sadler, 2005), where flexible materials such as textiles or membranes facilitate both structural and functional flexibility. Archigram “sought to escape from conventional theory and practice through experimentation with new forms and materials” (Knippers et al., 2011, p.14).

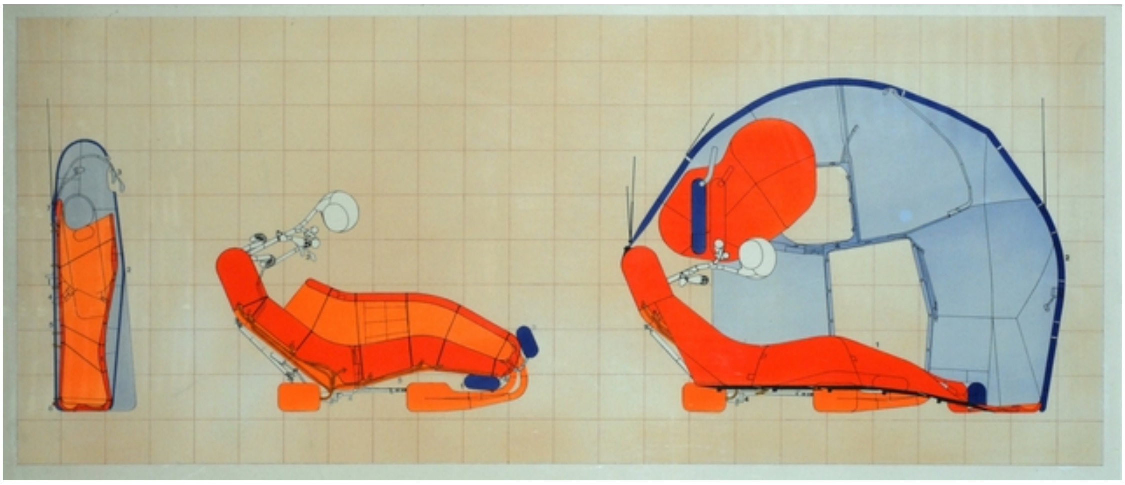

Figure 2-1: The Cushicle, 1964 and Suitaloon, 1967 by Michael Webb. Image source: Architecture Without Architects (2012).

Hence, structural and functional flexibility can be achieved by employing flexible materials such as textiles. Indeed, textiles have been remarkably used also for exterior and permanent use. For instance, in tensile fabric architecture, for their strength, stability and flexibility. These are structures, Garcia (2006) says, that consider exterior environmental conditions and are effective in extreme physical conditions, being able to withstand dynamic loading forces that can result in twisting, torsion, buckling and bending, such as those encountered during earthquakes, wind-directed heavy snow and during hurricanes. When constructed from lightweight glass and carbon fibres, especially in composites, the textiles are also faster, easier and cheaper to transport, making the construction process simpler and more efficient (Garcia, 2006, p.10).Textile flexibility together with tensile strength have further been utilised as an “alternative to conventional formwork materials for casting concrete” (Manelius, 2012, p.54).

We can draw from this, and our earlier discussions, that flexibility is significant for temporary structures, and may observe that materials such as textiles play a vital role in achieving and maintaining this trait. Many properties of textiles have been exploited in permanent and temporary construction, mainly for exterior use. Further research needs to explore extended uses, such as understanding the potential of these properties in the context of TSI space.

An interrelated point to consider here, is that while temporary structures, including TSI spaces, require flexibility, they also need to be structurally stable (Sandaker et al., 2011) (Brooker and Scarpa, 2007; Ching, 2015). Different systems of structure used by architects include load-bearing (traditional masonry buildings,), frame (Free plan buildings) and, recently, monocoque structure, such as the Lord's Media Centre, which was built in London in 1999.

However, loads and structure can be balanced differently, based on material properties and structure. Forces in Buckminster Fuller's geodesic dome, for example, are distributed evenly through the dome's outer casing of steel and aluminium interconnected triangles, rather than through (traditionally) heavy vertical and horizontal elements (Sandaker et al., 2011). This structure creates an uninterrupted interior space with less material and lower costs. Fuller's geodesic dome is one example of how a structure can be balanced utilising the same materials (steel and aluminium) but in different ways (in this case he uses tension instead of the usual compression and utilising gravity instead of opposing it) (Buckminster Fuller Institute, no date).

The above discussion aimed to highlight not only the importance of materials in the creation of space, but also to highlight the importance of the way materials are directed and handled to facilitate different functions of space, such as flexibility and structural stability. Here, we can conclude that both material (textiles) and the way it is used in a structure are interlinked factors in achieving both flexibility and structural stability central to TSI spaces.

2.2 Approaches to Materiality, Particularly Textiles, in Spatial Design

Materials used to be a neglected area in architectural discourse, in comparison to architectural space. For instance, as illustrated in Section 2.1, Lloyd Thomas (2006) argues that, historically, “material is rarely examined beyond its aesthetic or technological capacities to act as a servant to form” (p.2). Lloyd Thomas (2006) says that this is due to two factors. First, the architect is established as the form-giver in discourses and theories of architecture, which are mainly concerned with formal questions. Second, architectural methods of practice describe only form; for instance, orthographic drawing and reference material to marginal place.

Architects' interest in materials is growing. Material agency is increasingly recognised in recent literature (Baerlecken and Wright, 2014; Schröpfer, 2011; Skepper, 2016), not only in architecture, but in many disciplines of creative practice including art and garment design (Smelik, 2018; Woodward and Fisher, 2014). Steady change in the sense of materiality, along with new material innovations, continues to impact architectural theory and practice (Kretzer, 2017). Recent approaches to materiality question traditional views of “the way materials are perceived, experienced and understood” (Kennedy and Grunenberg, 2001, p.4). For instance, West and Coar (2012) challenge the common notion of materials as passive matter to be composed in an X-Y-Z coordinate system, and express their perception of matter as something living and active and interconnected. Ng and Patel (2013) introduce many critical accounts, ultimately viewing materials (even those perceived as static) not as passive, but in constant change. They also discuss the notion of material scale and highlight material perception beyond ordinary human senses, from micro to macro levels, from nano-scale technology to climate scale.

Thus, architects’ perceptions of materials and their relationship to matter have changed. Part of this is, as noted above, to do with new material innovation. On this matter, Decker (2013) states that architects “have dramatically extended their approach to making material composites” (p.77) in order to realise ideas that were unachievable with existing materials provided by the market (Klassen, 2006; Peters and Drewes, 2019). New materials are thought of as opportunities for more interactive and responsive functions in architectural design. They are thought to promote more interaction between spaces and their occupants. Decker (2013) explains that this was made possible through increases in cross-disciplinary scientific research. For instance, Kretzer's (2017) research joins the material world with the virtual world of computers in what he terms “information materials”. Kretzer (2017) investigates these materials’ abilities to sense and respond to environmental influences. Technological directions such as these are motivated by ideas of the ‘smart’: -ambience, -space and -built environment.

Also by new systems such as the Internet of Things. These architectural directions seek more performative, interactive and ‘smart’ materials.

Similar technological directions can be seen where textiles are used as a building material. In the last two decades, a considerable number of research projects on the borders of architecture, textile design, textile science and interactive design were conducted, often by multidisciplinary teams. For instance, in the UK, Robertson, Taylor and Bletcher’s (2019) research looks at programmable textile artefacts and industrial-scale manufactured products for architectural and performance use. Philpot's (2011) research uses different traditional textile techniques—origami-folding, as well as 3D printing—to develop new types of textiles, or textile hybrids, which have the ability to sustain three-dimensional, adjustable forms with little or no supporting substructures. The developed, small-scale textile-type prototypes of the latter project may well have potential application in architectural settings (Philpot, 2011).

A considerable number of Scandinavian-established architect-researchers, doctoral projects and research groups, e.g. ArcInTex,[3] explore advancements in textiles, interactive design and computational design. They also consider different functions in architectural design, such as energy harvesting, lighting and sound regulation, and applications of smart textiles in architectural settings, an example being Dumitrescu’s (2011) light-emitting textiles. In Denmark, Mette Ramsgard Thompsen, Head of Centre of IT and Architecture (CITA) at the Royal Danish Academy of Fine Arts, is a pioneer in textile use and smart textiles in architecture. She collaborated with the Institute for Computational Design at the University of Stuttgart to create several workshops and seminars (2009-2010) on these subjects. One workshop, ‘Textile logic: how to brace’, was focused on digital tools and the

[3] ArcInTex Network in which ‘Architecture, Interaction Design and Textiles join forces in developing ideas, techniques, methods and programs for new perspectives on design for building, dwelling and living’ (ArcInTex, 2019).

fabrication of variegated textile tension structures to examine intersections between textile design and membrane architecture. The workshop involved a multi-disciplinary group with different specialities, from textile design to textile engineering. Using advanced digital software and a CNC netting machine, students at the workshop explored ideas of material design and ways of using digital tools to create bespoke knitted textiles to tune material performance in membrane structures (Kolding School of Design, 2012).

From the above, we can conclude that newly invented types of textiles form one of the current research directions between spatial design and textile.

More broadly, there is considerable research investigating and promoting the use of textiles in spatial design and highlighting their application for different functions. For instance, Jakob and Collier’s (2017) research looks at the role of textiles in enabling sensory-enriched environments and meaningful activities for improving the quality of life of people living with dementia. Wærsted’s (2014) doctoral research is another study; focusing on motivating people to use textiles in architecture. My own master’s research project investigated the versatility of textiles and applications of smart fabrics in creating interactive displays in textile-based structures for stage design (Fallouh, 2010).

Besides the above directions towards developing new materials or applications, an additional school of thought indicates that new (or smart) materials are not the only route, arguing that “much material innovation emerges not in the making of new materials, but in transforming the way in which we handle them” (Schröpfer, 2011, p.23). For instance, Sauer (2010) highlights that “innovations are often based on the intelligent utilisation of structures or physical properties already inherent in the material, which implies working with, rather than in opposition to, the material” (p.157). Somewhat in agreement, Kennedy and Grunenberg (2001) highlight that even the most ordinary materials, by a re-examination of their very 'alchemical' properties, can appear to be many different things, as they transform states. Schröpfer (2011), too, explains that experiential and exploratory investigation of the inherent nature of material properties, at full scale (1:1) "prompts new insights into the formal, conceptual, and expressive potential of these materials for designers" (p.21). Thus, as Ashby et al. (2007) emphasise, "innovative design means the imaginative exploitation of the properties offered by materials" (p.2).

With this advice in mind, then, we might turn to consider the versatile materials that are textiles. As Loschek (2009) states, "The textile is used as a cover and as delimitation, whether of the human body, products (table, chair) or spaces (tent, tapestry)." (pp.15–16) As a material, it has specific physical properties and perceived qualities (Deplazes, 2013) that affect designers' expression. Textiles have inherent and developed physical properties, such as: span, lightness, malleability, thermal and acoustic insulation, flammability, lifespan, self-cleaning effect, resistance to chemicals, tensile strength, resistance to cheering, recyclability and temperature range (Koch and Habermann, 2004). They also have important perceived qualities, e.g. colour and pattern, texture, warmth, tactility and pliability. These various inherent and developed properties and qualities arguably make textiles an interesting architectural material (Krüger, 2009).

Besides this recognition of the importance of materials' inherent properties and how these are treated, architectural scholarship also emphasises the critical role of an architect's understanding of a material's properties. Acknowledging the architect as "being intermediary and the connection link between ideas and materials" (Schröpfer, 2011, p.8), this work considers the architect a "professional dilettante"; a kind of alchemist, who tries to generate a complex whole (Deplazes, 2005, p.19) and someone who is required to develop "the mindset and sensitivity of the maker" (Ayres, Tamke and Thomsen, 2013, p.131). Such tendencies towards understanding materials can be traced to the experimental work of the early 20th century. At that time, creative and important innovative personalities in architecture had creative ideas that played a crucial role in developing lightweight building systems, including fabric structures (Kronenburg, 2014). For example, Buckminster Fuller's experimentation with aluminium in the Dymaxion house project is lauded.

Scholars in architecture, such as Kennedy and Grunenberg (2001), further emphasise this cultural context of materials' uses: "the associations inherent in its cultural history—with the ways in which a material is used, perceived and remembered within the larger contexts of its production" (p.12). Likewise, Schröpfer (2011) stresses that many classic architectural materials "embody meaning that stems from the way in which they have traditionally been worked within […] the care, difficulty, and craft of its treatments within a culture" (p.21). Therefore, it is important to note that some materials have a cultural context beyond their architectural use—something which is particularly pertinent when it comes to textiles and their history of use in garment design and making.

This section has considered how spatial design, and predominantly architectural scholarship within this, has considered the relationship between materials' inherent properties (including textiles), innovation, the skill and experience of the designer and the significance of material use beyond its architectural context.

In this research, while my interest in textiles was motivated by recent advancements and new textile innovations, I argue that spatial designers can benefit from textiles' inherent properties, such as their flexibility and ability to fold and drape, by observing their use in architecture and in the wider context of use, particularly in garment design. This research highlights the importance of designers' understanding of materials and their skills and expertise.

In the next sections, I will examine past and present textile use in spatial design (in an architectural context, including interiors) and beyond; most importantly, in garment design and construction.

2.3 Spatial Design and Textile Use

This section aims to understand how textiles have been engaged within spatial design, and considers current design directions and their origins. It will cover several related theoretical and contextual aspects, such as its previous marginal position in architectural theories, history and practice, and architectural motivations for renewed interest. It begins by discussing different types of engagements between architecture, interiors and textiles. It then focuses on textile use (and textile composites) as a construction material in spatial design, with a focus on TSI spaces to highlight the role of material development and skill transference in the development of these structures. In doing this, I aim to understand and identify current design and construction approaches of TSI spaces.

2.3.1 Previous Marginal Position

The use of textile in architecture is ancient. However, the relationship between architecture and textiles has had a marginal position in the central theories of architecture and its practice for large swathes of history (Garcia, 2006b). Different factors contributed to this marginal position before the 20th century—a point in time that marked the invention of more developed and sophisticated types of textiles (Kronenburg, 2014; Garcia, 2006b). Conversely, our knowledge about textiles in interiors is preserved in better conditions than in architecture (Garcia, 2006b).

The main contributing factors to this marginality in the record are previous textiles' limitations and the lack of surviving examples, and a negative perception of textiles' properties as temporary, flammable, fragile and unstable (Garcia, 2006b; Kronenburg, 2014; Quinn, 2006). Early prehistoric dwelling textiles, such as tents, are dismissed in Western architectural history, which starts with permanent, solid, monumental stone buildings (Kronenburg, 2014). Garcia (2006b) notes that 'intellectual' disciplines of art and design, such as engineering, sculpture and architecture, were viewed as superior to 'manual' and prosaic pursuits, which involve tacit, physical and object-embedded knowledge, such as that of tent-makers, tailors, couturiers, weavers, sail-makers and textile designers. Likewise, Scheer (2014) highlights that, during the Renaissance, due largely to the writings of Renaissance architect and philosopher Leon Battista Alberti,

> Architecture became a purely intellectual endeavour and the architect's proper domain of knowledge was what we would call theory: the reasons why buildings should be designed in certain ways. Furthermore […] knowledge of "why" to be superior to the builder's knowledge of "how", placing the architect above the builder as the true author of a building. (p.2)

Garcia (2006b) indicates that since the tacit physical efforts of designers and makers and their experiential expertise were thought unworthy of recording, preserving or scholarship, this led to a lack of recorded knowledge and documentation of design and making, and therefore our knowledge about early examples is patchy.

Identifying another cause for textile architecture's marginality, Kronenburg (2014) shows that the functional requirements of lightweight temporary textile structures drove their architectural development. For instance, Kronenburg (2014) states that early civilisations located in temperate locations did not require environmental modifications; consequently, such structures (apart from elements such as roofs) were not demanded.

2.3.2 Renewed Architectural Interest in Textiles: Theory, Practice, Research and Types of Engagements

Despite broad marginality, interest in textiles and architecture has undergone flourishing and declining periods throughout their long history. Of interest to this study, is a renewed interest within the past twenty years in particular, in the hybrid area of architecture and textiles. This interest is marked by: 1) research projects related to textile invention (see Subsection 2.2); 2) research groups and networks (e.g. ArcInTex, mentioned above); 3) publications that highlight the potential of textile innovations in design and architecture (such as books including those by Addington and Schodek, 2005; Quinn, 2010; Colchester, 2007; Krüger, 2009; Braddock Clarke and O'Mahony, 2007; Sauer, 2010; magazines including Fabrics Association International [IFAI], 2020; journal articles and full issues including Architectural Design's special issue to Architextiles in 2006 and the Textile Journal, also 2006); 4) exhibitions such as the Extreme Textiles Exhibition (McQuaid, 2005) at the American National Design Museum Cooper-Hewitt in New York; and 5) built projects (such as the Cruz y Ortiz Metropolitano Football Stadium, Madrid, 2017, Foster and Partners' Hydro, Glasgow, 2011, Nicholas Grimshaw's Space Centre Rocket Tower, Leicester, 2001, Richard Rogers' Millennium Dome, London, 1999, and Michael Hopkins' Dynamic Earth, Edinburgh,1999). This architectural surge highlights continuing and fresh exploration, potential and interpretation of the subject, in theory and practice.

Garcia (2006a) defines the hybrid term 'architextiles', that has originated within this recent surge, to express "a wide range of projects and ways of thinking that unite architecture and textiles" (p.5). The expansion of architextiles is related, Garcia argues, to key drivers such as the advancement of materials and material science, engineering, manufacturing, technological advancements, economic and socio-cultural developments (2006a; 2006b). Additionally, its growth is attributable to post-modern theories of space (Garcia, 2006a; Coates, 2006), e.g. Deleuze's text on the 'Fold' (Garcia, 2006b) and Zygmunt Bauman's writings on 'liquid modernity' (Tzanoudaki, 2011). These theories, in opposition to classic Vitruvian static ideas, "promote architecture that is never finished, never static, but in a continuous state of becoming" (Garcia, 2006a, p.8).

Garcia (2006b) identifies another driver when he argues that, with technology—"the computer and the digital meshes of building skins and NURBS[4] surfaces" (p.16)—architecture began to adopt textile-related qualities in the 1990s. Although, as the literature shows, before the advent of these technologies, the biggest revolution of computational form-finding dates back to 1970 (Simmonds, Self and Bosia, 2006). Architects have been utilising qualities of textiles for form-finding/generating since Gaudí's hanging chain models in the early 1900s, to the works of Frei Otto and the Institute of Lightweight Structures in Stuttgart's intensive research in the 1950s–1960s and Heinz Isler's concrete shells (Chilton, 2010; Goldsmith, 2016; Tramontin, 2006; Simmonds, Self and Bosia, 2006). Fundamentally, what we can see is that, over recent decades, textiles have demonstrated unique opportunities to adopt technology, and architectural attentiveness to textile use has developed with advancements in material technology (Wakefield, 2006). Consequently, textiles have been altered from furnishings-only, in the eyes of many, into something just as likely to be perceived as construction material (Garcia, 2006; Hoskyns, 2007; Quinn, 2003).

Looking in more detail at how architecture and textiles engage with one another, Garcia (2006a, 2006b) identifies several, often overlapping, dimensions. First, textile use or textile-processes are utilised as a metaphor in architecture, for instance, "when a space is described as being woven or knitted" (Garcia, 2006a, p.8). This is especially relevant in the works of Lars

[4] NURBS: "stands for Non-Uniform Rational B-Splines, is an industry standard for designing and modelling surfaces. It is particularly suitable for modeling surfaces with complex curves." AUTODESK (no date).

Spuybroek, for example, who termed it the "textile way of thinking" (Garcia, 2006a). Spuybroek's experiments of structural weaving and braiding using paper strips in the public artwork pavilion of Son-O-House (Figure 2-2) (Garcia, 2006, p.53; Spuybroek, 2005, p.15).

Figure 2-2: Left, paper model of the Son-O-House pavilion. Right, accomplished pavilion, (NOX) Lars Spuybroek, Netherlands, 2001-2004. Image source: Spuybroek (2005, pp.15-16).

Second, is when a textile-like spatial structure is produced,[5] e.g. the works of architects such as Nigel Coates, Will Alsop and Dominique Perrault. However, reviewing the literature shows that similar engagements are traceable to the 16th century, as tent-inspired roofs became popular for castle turrets, palaces and churches. One notable example is the copper-roofed pavilion at Drottningholm, Sweden, 1781, in the style of Ottoman military tents (Drew, 1996). Another example from twentieth-century architecture is Eladio Dieste's brick church (Donadussi, 2004), where 'textile logic' can be traced by translating the 'logic' or geometry or movement of textile structures into solid materials (Brick).

[5] This classification implicitly consider engagements with textiles to encompass engagement with garment design (See Subsection 2.5.2)

Garcia (2006a, 2006b) and Coates (2006) identify a third dimension where architecture engages with textiles in theoretical and fictional writings.[6] For instance, Coates (2006) argues that architects “have used the textile as a conceptual tool for liberating form from the usual constraints” (p.46) in line with Deleuze’s ‘The Fold’, a study of a pliant surface. This dimension can be traced back to nineteenth-century theorising of architecture concerning textiles, as highlighted in the writings of the German architect, historian and theorist Gottfried Semper—especially his notion that the “beginning of buildings coincides with the beginning of textiles” (Semper, 1989, p.254). Semper explains how, originally, especially in warm countries, woven fabrics functioned as visible spatial dividers and that the creation of solid walls was to create a holding structure, which is completely covered by woven fabric (Semper, 1989, p.24, 255). Semper’s writings are widely cited in textile-architecture and have influenced later twentieth-century post-modern theories of space (Garcia, 2006).

Textile engineer Wærsted (2014) argues that some architects engage with textiles only as an ‘extra’ or ‘add-on’ to be added or ‘hung’ at the end of the architectural process. Wærsted identifies, however, that textiles are engaged in the design process as a design media, and that this can therefore be understood as a fourth dimension. The fifth and final dimension that Wærsted (2014) and Garcia (2006a, 2006b) both identify, and one that is of interest to this research, is textile use (or textile composites) in actual structures. The next subsection will review some of these sorts of structures. However, before that, I would add a sixth dimension: textiles used as an intermediary material in formwork, such as that for concrete in Walter Jack’s ‘Crushedwall’ in the Heartlands project, 2012, Cornwall, UK. Although this type of engagement arises from the works of architects Kenzo Unno and Mark West

[6] Barnett (1999) draws on visual artist Yve Lomax (2000) observing Michel Serres’s textile metaphor as ‘soft logics’, when she mentions Serres’s rigid little boxes (small boxes which fit inside bigger ones) in comparison to fabric sacks where multiple sacks can be folded inside one sack, featuring ‘box-thought’ in contrast to ‘sack-thought’.

in the late 1980s and early 1990s (West, 2016), related work and research are also conducted at the School of Architecture and Landscape Architecture at the University of Edinburgh (Pedreschi, 2007), and in some “recent doctoral completions—Lee (2011), Hashemian (2012), Mane-Llius (2012), and Orr (2012)” (Pedreschi, 2013, p.897).

2.3.3 Textile Materialisation in Spatial Design (Exterior and Interior Use with a Focus on TSI Spaces)

In this section we will see that before material developments in the twentieth century, breakthroughs largely occurred through transference of skills, such as the transference of sail and maritime skills into construction. After the twentieth century, when new materials were available, material developments and skill transference played tandem roles. This part of the review will also focus on tracing and tracking variations and developments of different architectural approaches (methods, techniques and structural principles), whilst recognising the impact of context on this process. For instance, the impact of the historical period, scale, use (exterior, interior), function (personal dwelling, social), intention (pragmatic, expressive, sustainable, smart), geographical location, climate and environmental conditions. This review encompasses published literature and contextual sources, and materials collected from visits to precedents that were part of the Edinburgh International Festival and Edinburgh Festival Fringe in 2011.

Pragmatic textile use occurred in pre-historic structures; mainly in tents, which are considered one of the earliest forms of fabric structures. Kronenburg (2015; 2014) explains that examples of early traditional portable tents are the North American tipi (tepee), the Asian yurt (ger) and the Bedouin black tent of North African nomads. Considering design and structure, Huntington (2013) notes that these tents were pragmatic; their construction methods and principles were coherent with their climatic and environmental conditions. For instance, the steep slopes of a tipi do not easily collect snow and provide a chimney for fire. Whereas the Bedouin tent's low profile and shallow slopes resist the desert winds. Accordingly, Huntington (2013) explains that three main form types can be identified within traditional tents: conical, such as the North American tipi; tensioned into saddle shapes, such as in the North African Bedouin black tent; and cylindrical, such as the Asian yurt (ger). Huntington (2013) also remarks that the fabric of the black tent is a structural element; while in the other two types, fabric serves as a cladding material and is not an integral part of the structural system. He also highlights that, from a structural standpoint, the black tent's basic anticlastic surface (where it has opposite curvatures at a given point) and structural system have similarities with contemporary tension fabric structures. Faegre (1979) also highlights that tent qualities, such as those of portability, lightness and flexibility, have been applied to much modern and current architecture.

Although tented buildings have existed for millennia, most historic examples were in scale (not as massive as current structures). A remarkable increase in the size and capabilities of these structures to work on a much larger scale was only really seen upon the development of shipbuilding and sails, and the transference of these skills to architecture. Although Kronenburg (2015) and Garcia (2006b) note that examples of large-scale fabric structures make a patchy appearance in the history of Western architecture, as mentioned in Chapter 1, one remarkable example of this particular transference is a retractable awning, a tensile roof of canvas called a 'velarium' or 'velum' (the Latin word for sail), used to cover the Colosseum. This is documented as having been constructed by sailors who would have been familiar with sail-making technology during the Roman Empire. In addition, another type of smaller tent in that period was the Roman military tent (Berger, 1996; Drew, 1996; Kronenburg, 2014; 2015).

In the eleventh and twelfth centuries, tents re-emerged in Western European architecture. They did so most notably in France—probably as a result of the Crusades (Drew, 1996). Campaign tents were also used in Asia, and here it is noted that tented buildings sometimes had greater symbolic importance within another structure, such as was the case with Ottoman and Persian tented palaces (Drew, 1996; Kronenburg, 2015). Campaign tents were also used in the Middle Ages throughout Europe (Drew,1996; Kronenburg, 2015). The most predominant types depicted in late medieval art were circular, parasol-roof tents and draped pyramidal canopied tents (Drew, 1996).

Moving on through history, during the Renaissance, skills transfer created grander structures. Maritime techniques were used to construct notable fabric structures, due to the necessity for specialised buildings to accommodate royal gatherings and theatrical performances. Great temporary banqueting and royal entertainment halls were built (Drew, 1996; Kronenburg, 2014; 2015). A well-known example is the Field of the Cloth of Gold, erected to accommodate a meeting held by the Tudor King Henry VIII, in northern France, 1520 (Drew, 1996; Kronenburg, 2014; 2015). Due to the cessation of royal tournaments, the use of tents declined, except for military purposes (Drew, 1996). However, according to Junyk (2014), by the sixteenth century, a few types of lightly constructed buildings became popular thanks to the influence of the tent, and one of these forms was the particularly ornamental and tent-like building that is the pavilion. Thus, a descendent of the tent, the pavilion entered the European landscape. It was joined by others such as the kiosk (Drew, 1996).

Between the eighteenth and nineteenth centuries, the pavilion was perceived as a “humble folly” all the way up to the “avatar of the nation” at different sites, and was commonly found at expositions and world fairs (Junyk, 2014, p.2). Despite being ephemeral, tents were re-sited either in other locations or in “the archives of cultural memory” (Junyk, 2014, p.2). Tent structures continued to develop during this period— the circus tent originated from the symbolic circular tension tent, with its roots in the trick-riding shows and travelling menageries of the eighteenth century (Kronenburg, 2015; Kronenburg, 2014). In the late nineteenth and early twentieth centuries, many European and North American circus tent manufacturers were founded, such as the famous German company Stromeyer and Co., in 1872. Also, the US Tent and Awning Co., in 1906, provided tents mainly for the circus, but also for carnivals, performance and increasingly popular moving pictures (Drew,1996; Kronenburg, 2014; 2015). Kronenburg (2014; 2015) notes that these tents were located in parks and rural areas near the city, as they required flat land and guy ropes, made from tensioned membrane in a lightweight tent shape; while framed tents inside cities utilised wood or metal frames as their main structural element, with fabric used as a waterproof layer.

Despite there being only patchy knowledge about historical textile structures, knowledge about textile use for interiors is actually well-kept (Garcia, 2006b). According to Lasc (2016), during Roman times, the Middle Ages, the Renaissance and the eighteenth century, all the way through to the second half of the nineteenth century, textile use was associated with wealth and status. This association reached its peak during the eighteenth century, a period marked by a new requirement for comfort. In this century, textile use was either in soft furnishings, such as upholstery, wall coverings and draperies, or as space-defining draperies, hung from the main structure of the solid building to create partitions, and for decoration (Ramsgaard Thomsen and Bech, 2016). For instance, according to Lasc (2016), fabrics in a room moved from padding and decorating to also delimiting spaces within spaces. Tented high-profile interiors emerged, for instance, such as that at the Charlottenhof Palace by German architect Schinkel (Garcia, 2006b; Ramsgaard Thomsen and Bech, 2016) (Figure 2-3). In theatres, stage textiles served as a traditional component of stage flats, backdrops, cyclorama or curtains (Crabtree and Beudert, 2011; Hoggett, 1975).

Figure 2-3: Tent room in Charlottenhof. Image source: Ramsgaard Thomsen and Beck (2016, p.63).

Ramsgaard Thomsen and Beck (2016) remark that, through Modernity, “[the] general use of textiles has become reduced and subordinate to architecture’s other material practices” (p.78). However, in the twentieth century, the interior use of textiles or textile-inspired elements continued, influenced by Semper’s theories about textiles and architecture (Houze, 2006). Some Modern architects used textiles—for instance, draperies, carpets, upholstery fabrics—to define interior space (Houze, 2006). Also, key architects such as Mies van der Rohe collaborated with textile designers in projects outside of these private interiors that employed the richness and complexity of textile space (Kalassen, 2006; Ramsgaard Thomsen and Beck, 2016). For instance, in the

Velvet and Silk Café, Women's Fashion Exhibition, Berlin, Germany, 1992 suspended curtains were used as space dividers (Figure 2-4).

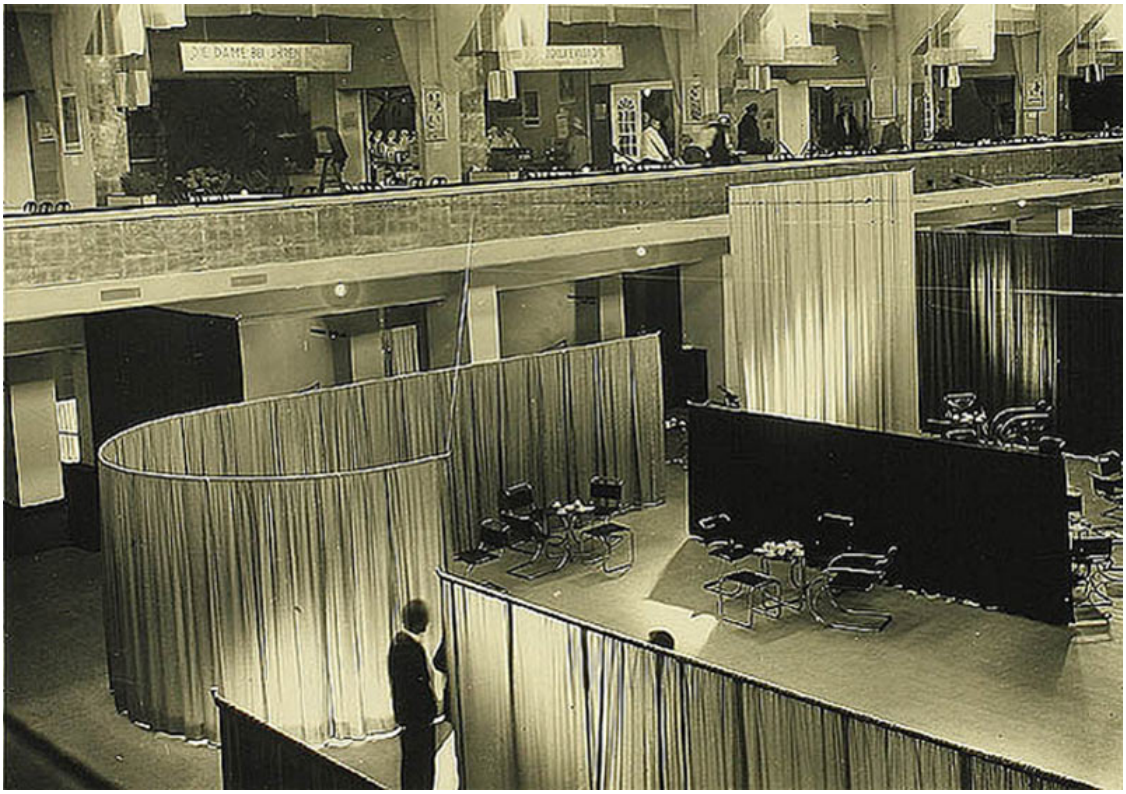

Figure 2-4: The Velvet and Silk Café by Ludwig Mies van der Rohe and Lilly Reich (1927). Image source: Fabrizi (2016) (internet).

Kronenburg (2014; 2015) and Drew (1996) illustrate that textile-based constructions in the twentieth century were driven by the Industrial Revolution and business expansion, which raised the requirement for exhibition, entertainment and event structures in Europe's major cities and in the US. These were “often temporary […] and require a strong image” (Kronenburg, 2015, p.8). According to Drew (1996), the prestige of nineteenth and twentieth century suspension bridge technology, which followed developments in the use of iron and steel, influenced the expansion of new types of tension structures that could be utilised or experimented with in these textile-based constructions. Cable net structures, for instance, were the precursors of contemporary tension fabric structures (Huntington, 2013). Examples of early adaptations of this technology for buildings were created in several European countries, such as Slovakia, Bohemia and France, and later in Russia in the notable All-Russian Exhibition by Russian engineer, polymath, scientist and architect Vladimir Shukhov, a pioneer of tensile architecture, in 1896 (Drew, 1996). These structures attracted attention and became widespread over the following decades (Knippers et al., 2011). In this period, we can observe knowledge transfer working in tandem with technological and material advancement, as canvas fabric was replaced by more waterproof synthetic materials, and masts were replaced by aluminum-framed structures raised by cables (Knippers et al., 2011; Kronenburg, 2014; 2015).

The development of tensile fabric architecture is mostly attributed to Frei Otto, introduced earlier, who was influenced as a student by cable net structures, such as those at the J.S. Dorton Arena, in North Carolina, during a visit to the US (Huntington, 2013). In parallel, Otto collaborated with circus tent manufacturer Stromeyer, which had an important impact on the development of contemporary fabric structures (Kronenburg, 2015). Unlike most architects of his time, Otto's work manifests an important departure from the principles of bridge-based engineering (Drew, 1996; Huntington, 2013), as the first examples of tension fabric structures pioneered by Otto were small bandstand designs (see Figure 2-5).

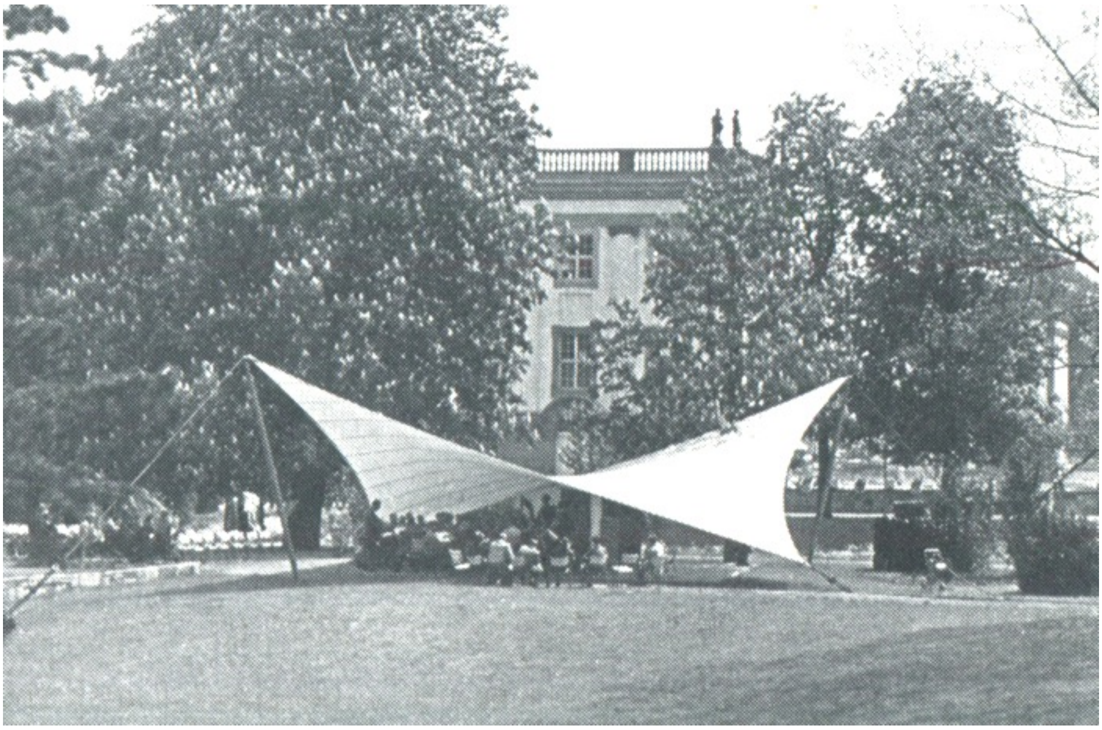

Figure 2-5: Federal Garden Pavilion, Kassel, Germany, by Frei Otto (1955). Image source: Kronenburg (2014, p.94).

As Kronenburg notes, Otto's "personal experience in aviation and economic hardship in pre- and post-war Germany informed his design, leading him to search for more economic, yet also innovative, building solutions" (2015, p.8). Goldsmith (2016) adds, based on his personal experience in working with Otto, that as the son of a sculptor, Otto saw that model-making required an "appreciation of the scientific equations describing nature" and "an understanding of materials, structure and form that made it possible to create new structures" (p.26). Traditionally, the architectural design process is assumed to be a rational linear one, which fosters a shape-making design approach based on personal visualisations. However, Otto used a form-finding one. In Goldsmith's words: "as Frei once told me [Goldsmith] about using the form-finding process, 'the architect is acting more as a midwife than God the creator'" (2016, p.26). Goldsmith (2016) also notes that Otto was "absorbing techniques from the masters that went before, such as Gaudi, with his hanging chain structures and photographic measurements, but he modified them for his own use and special vision, and these techniques still stand today" (p.28), such as in parametric design—the design of complex geometries and structures.

Tension fabric structure designs at this time were limited in size because of insufficient strength in fabric materials, such as polyester (Huntington, 2013; Kronenburg, 2015). Engineering technology had advanced into textile technology during Otto's time; thus, to compensate for insufficient fabric strength, polyester fabric was hung on cable network technology. Achieving a longer lifespan of these structures had to wait until the architectural value of PVC and PTFE-coated fibreglass was realised in the 1960s (Kronenburg, 2015).

Another type of fabric structure developed in the twentieth century is the air-supported structure/roof. This structure provided an economic solution to achieve long spans (Huntington, 2013). Although such structures were first patented in England in 1917, their physical realisation had to wait until 1946, when Walter Baird pioneered the Radome in the US (Huntington, 2013). Not long after this, cable domes, based on Buckminster Fuller's tensegrity dome, were developed in the 1950s (Huntington, 2013).

Collaboration between engineering and architectural firms designed and constructed increasingly ambitious exhibition buildings during the twentieth century (Huntington, 2013). In the US, the FTL Design Engineering Studio created a fabric building for the Olympic Games in Atlanta, US, in 1996, the fabric skin of which formed a projection screen for video images (Kronenburg, 2015).

From the year 2000 to the present day, fabric structures continue to be built worldwide, mainly by European, American and Japanese firms. Simultaneously, fabric structure technologies and fabric/membrane manufacturing have been in constant development. An important body of research developing established architectural approaches, such as tensile structure, is currently in progress. For instance, we can look to research at the Institute for Computational Design at the University of Stuttgart, the work of architects Michael Hensel, Achim Menges and Sean Ahlquist, that of structural engineer Julian Lienhard (Hensel and Menges, 2008), and techniques involving hybrid forms and bending-active structures (Ahlquist, 2016; 2015). Furthermore, textile-based structures continue to be used for temporary occasional use, such as events, festivals, expo shows and performance.

In 2011, I took an exploratory visit to observe textile use in the Edinburgh International Festival and Edinburgh Festival Fringe. I was a participant observer for one day at the installation of the MIRAZOZO luminaria: an inflatable structure, which contained a multi-sensory space based on the effect of space, colour and natural light (Figure 2-6) (for participant observations and interview transcriptions from this visit, please see Appendix 2, Section 2.2). I also observed and examined the Violet (Figure 2-7), a portable mobile theatre, which hosts a sequence of daily shows over the Festival period. This pop-up theatre combines the principles of a load-bearing frame and tensile structure, in addition to non-structural inflatable parts. These field visits provided important insights into the practicalities of textile-based structure design and fabrication in practice and their current use of textiles.

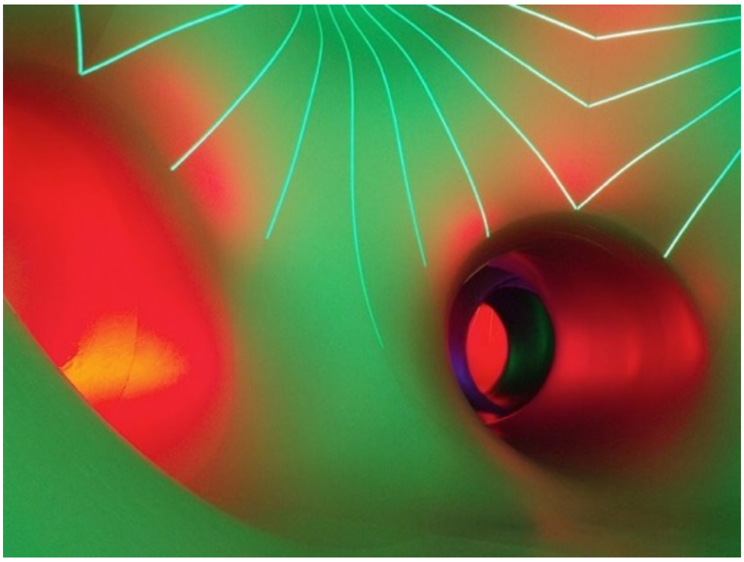

Figure 2-6: Top—the interior of the MIRAZOZO luminaria inflatable structure by Alan Parkinson, Architects Of Air (2011). Bottom—details of MIRAZOZO (air-tight zips). Image source: by author.

Figure 2-7: The Violet—a portable mobile theatre installed in Bristo Square, Edinburgh. Image: Kettle (2015) (internet source).

Besides tent-like structures and their outdoor use, such as that seen in the Edinburgh Festival example, textiles have been used to build interior structures or, as defined in Chapter 1, TSI spaces, which reside in architectural envelopes. Goldsmith (2013a), an FTL senior principal who worked directly with Frei Otto, is one of the few who formally recognises these spaces in their writings, and refers to applications of interior tensile structures as 'tensile fabric interiors'. He observes that interior architects and designers started to accept fabric technology for indoor commercial spaces in the 1990s. Just as drapes and curtains are interior fabric structures today, Goldsmith predicts that tensile fabric interiors will be essential for the interior designers of tomorrow.

Below, I survey TSI spaces that emerged in the second half of the twentieth century. These spaces are designed by architects, interior designers and artists. For instance, American-Lithuanian artist Aleksandra Kasuba built innovative environments and fabric installations of tensile structures from

1971–1972 (Goštautas, 2009). Using two-way stretch nylon fabric, Kasuba conceived and built some of the first documented interior art environments (Goldsmith, 2013b) (Figure 2-8).

Similarly, German architect Gisela Stromeyer—the daughter of the circus tent manufacturer Stromeyer—collaborated with Otto in the development of tensile fabric structures. She designed a translucent sail-like structure made from spandex for an advertising agency's office in New York, US, in 1994 (Figure 2-9). These sails divided the space into working areas. Additionally, in 2002, for Elie Tahrani's showroom in the New York fashion company, she designed vertical fabric sails composed of translucent inflammable spandex, which divide the space into four parts that can be connected for large events (Figure 2-9). Textile surfaces in Stromeyer's projects are attached to walls and ceilings using hooks, and to the ground using movable weights. These two projects follow the same fabric tension principle, with minor variations in details, so the final results look similar. More recently, artists such as Anish Kapoor, Rachel Whiteread and Bill Viola have produced soft sculpture and installation works that cross the boundaries between art, architecture and materials science (Klassen, 2006).

Besides the above, architects use textiles as a covering material to a load-bearing rigid structure in other approaches. For instance, Iraqi-British architect Zaha Hadid used translucent fabric as a covering material stretched over a load-bearing steel structure, parts of which were suspended from the main structure in Manchester's Chamber Music Hall (Figure 2-10). It is remarkable, for this structure, that textile is transformed into a rigid surface and did not maintain its ability to drape and fold.

Figure 2-8: THE LIVE-IN-ENVIRONMENT by Aleksandra Kasuba, New York City, 1971-1972. Image source: Kasuba (1971) (internet source).

Figure 2-9 Top: spandex translucent sail-like structure, advertising agency's office in New York, US. Bottom: fashion company New York, US. Image source: Krüger (2009, p.54).

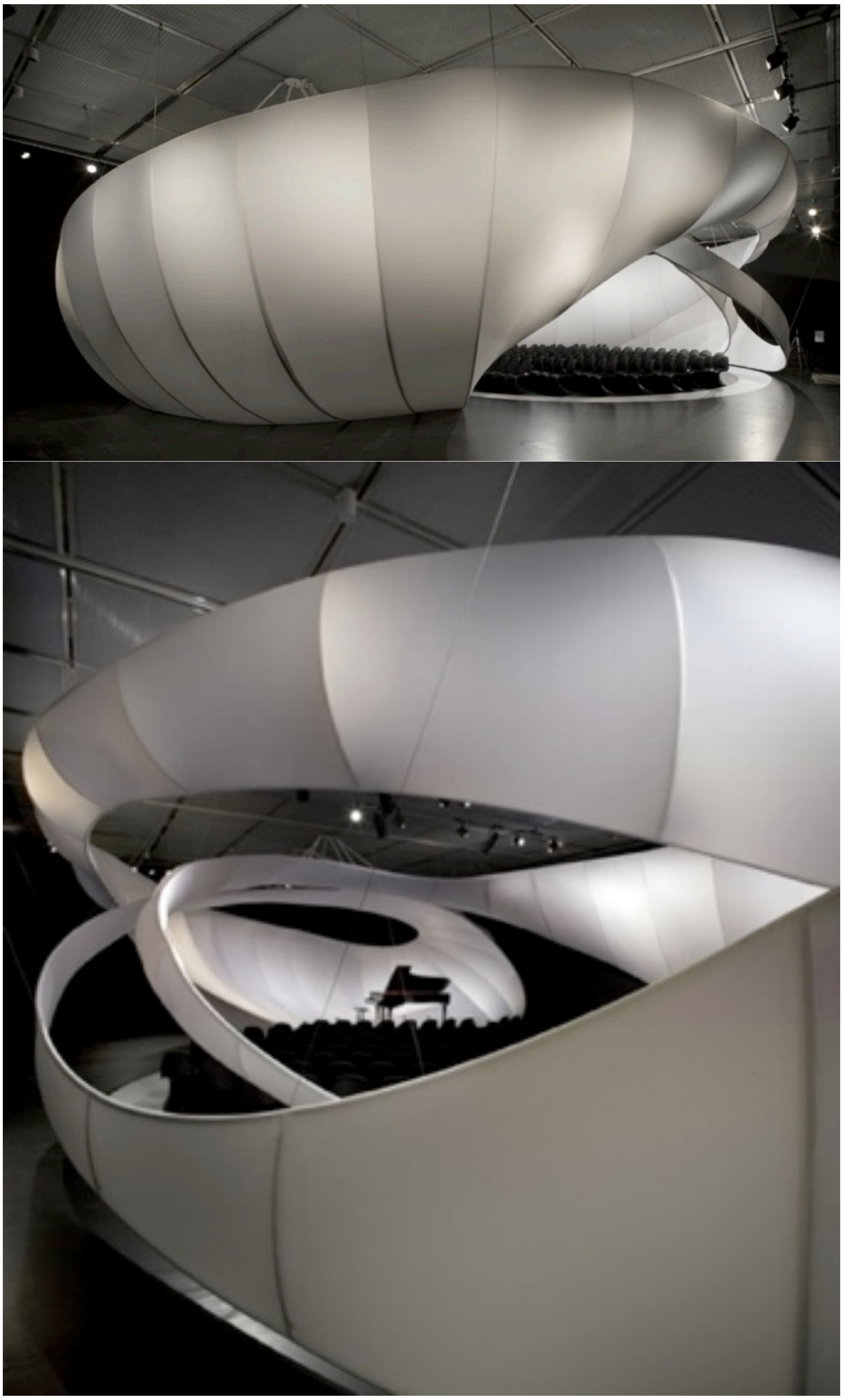

Figure 2-10: Zaha Hadid, the Chamber Music Hall (Manchester International Festival), textiles stretched over a steel structure, 2009. Image source: Zaha Hadid Architects (2009) (internet source).

Dutch designer Petra Blaisse takes another approach in her use of suspended textiles (Figure 2-11), which is reminiscent of the Silk Café (in Figure 2-4), as suspended curtains glide along tracks on the ceiling to constantly reconfigure the space inside the pavilion, highlighting possibilities to transform existing underused space. The curtains are comprised of panels with variable levels of opacity, including fine gauze, heavy velvet and shiny metallics (Blaisse, 2009). Blaisse's work demonstrates the use of many natural properties and qualities of textiles, such as their visual and acoustic properties, to control and change space. Related work by the American artist Janet Echelman creatively uses the principle of suspended textiles in a dance sculpture; for instance, her recent collaboration with Polish choreographer Katarzyna Kozielska (Figure 2-12).

Figure 2-11: Curtains used to transform a space, Dutch Pavilion at the Venice Architecture Biennale, 2012, Petra Blaisse. Image: Dezeen (2012).

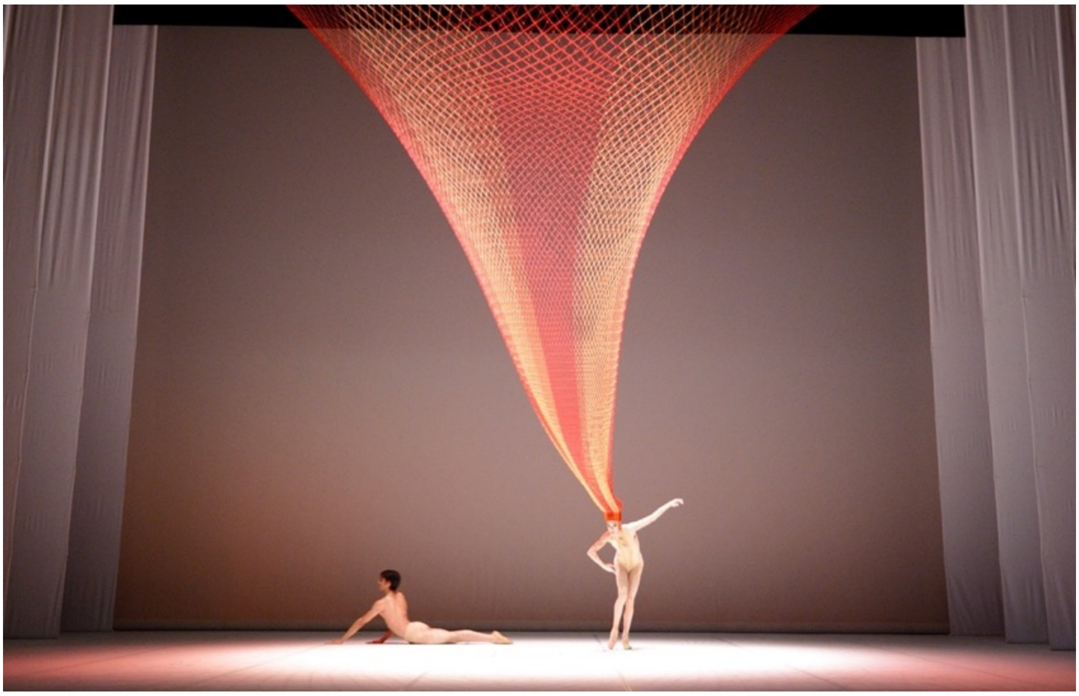

Figure 2-12: Artist Janet Echelman's sculpture for the 'A. Memory' performance at the Staatstheater, Stuttgart Ballet, Germany, 2014. Image source: Echelman (2014) (internet source).

In two visits to venues at the Edinburgh Festival and Edinburgh Festival Fringe, 2011, I observed textile use in the Die Frau Ohne Schatten Opera, performed in the Festival Theatre, where scrim fabric was used as a transparent screen for animated graphic projections (Figure 2-13). Additionally, a pop-up stage for the play Those Magnificent Men used a painted cloth suspended from a cubic metal frame, connected to the main structure of the mobile theatre (Figure 2-14). Festival shows take place in actual theatre spaces; however, Fringe shows reside in large mobile temporary theatres that occupy different open spaces in the city. Multiple short shows often share the same venue on the same day over the festival month, which leaves limited time to install sets for each show. Therefore, these tend to be practical, lightweight sets, which require speed and ease in their installation. Thus, textile use in these shows was anticipated, as it can satisfy these needs. I discussed stage materials and techniques with key players of this play's stage design. Textile use was limited to either a backdrop or a scrim for projection (see Appendix 2).

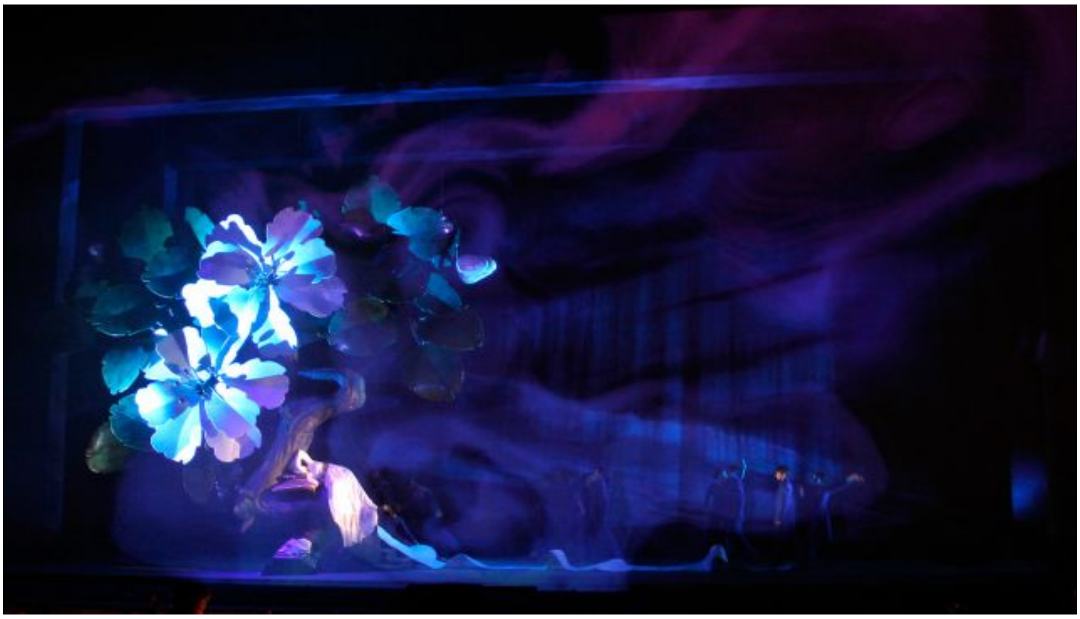

Figure 2-13: Die Frau Ohne Schatten Opera, Festival Theatre, 2011. Photo: by author.

Figure 2-14: Those Magnificent Men, Edinburgh Fringe, 2011. Photo: by author.

In Conclusion

This Subsection has highlighted that the current textile use in TSI spaces draws on architectural principles can be categorised into three main categories:

First, those that draw on tensile architecture principles. This review showed that tensile fabric architectural approaches transfer suspended bridge engineering technology—which shares its architectural scale and exterior use with buildings—to building design and fabrication. While these approaches have been efficient, especially in tackling natural loads and environmental factors in exterior use, in interior settings, however, where there are no such loads, apart from the force of gravity, architectural approaches can involve unnecessary constraints that limit the design of TSI spaces. In general, tensile fabric architectural projects are not self-supporting forms and require to be attached to the four planes of the spaces they occupy. Furthermore, they require specialist engineering knowledge to be realised.

Second, textiles as a wrapping material over a load-bearing skeleton. Stretching fabric over a rigid structure obliges textiles to behave in a specific way that fails to fully explore and exploit textiles' inherent properties and behaviour.

Third, textiles as an interior/exterior vertical space definer, such as suspended curtains, partitions or backdrops. Although these are different from tensile or load-bearing frame structures, they retain textiles' natural physical property to drape. However, such designs still require to be attached to the main structure of spaces they occupy and do not allow for much freedom regarding design and structure.

The first two approaches that use textiles to materialise architecture have been determined mainly by the needs of exterior use, such as tackling environmental factors and forces like wind, snow and rain, while in interiors, textiles have been used for reasons of comfort, wealth and status, to delineate and control the interior environment.

This Subsection also reviewed current research directions about the use of textiles in spatial design. It showed that these directions aim to advance currently established approaches from a disciplinary perspective, e.g. computational design development of tensile fabric architecture. Conversely, this research aims to examine a different route to explore the further potential of textiles and their properties beyond an architectural context. I saw garment design as a distinct approach to constructing three-dimensional forms out of textiles.

While architects follow their accustomed approaches when working with textiles, they are not necessarily trained in tailoring skills. Unlike garment designers, textile is one architectural material amongst a range of material options. Garment designers frequently handle textiles and have gained a large body of accumulated experience over garment-making history. This research studies textile use in its wider context beyond architectural exterior use and looks at garment design and construction.

In the next section, I will investigate garment design approaches (methods, processes and principles) to design and construct garments and possible methods that can be ‘transferred’/integrated into spatial design.

2.4 The Use of Textiles in Garment Design and Construction

Coming from a spatial design background, building a level of knowledge in garment design concerning how textiles are used in garment design and construction was required to undertake this interdisciplinary research.

This section highlights the centrality of textiles in garment design. It reviews the literature surrounding garment design related to fashion studies and its renewed interest in garment design practice and materiality. It then focuses on garment design and construction. This includes history, developments and practice; in particular, methods and techniques used in historical and contemporary sculptural garments.

Textile has been central to clothing throughout history. Natural animal and plant fibres were the main sources until the twentieth century and the invention of synthetic fabrics (Hallett and Johnston, 2014). More recently, high-tech and ecologically and ethically acceptable textiles have been at the forefront of practice and research (Loschek, 2009). Townsend and Goulding (2011) highlight that a unique physical and aesthetic relationship joins 2D textile surfaces and 3D garment shapes on the body. Silhouettes have defined fashion history and shaped the body's contours, and have a relationship with undergarments. Jones (2005, p.90) emphasises that although garments have been perceived as a silhouette, garments are three-dimensional, and are "viewed in 360 degrees—moving, bending and revealing its volume" (Figure 2-15). While the body holds the garment, its "structural integrity requires the organisation of parts into a consistent whole" involving undergarments (Scheller and Kunz, 1998); thus, they state, proper construction and appropriate materials generate structurally integral garments.

Figure 2-15: Developments in garment silhouettes 1775-2020. Image source: Jones (2005, pp.20-23).

2.4.1 Fashion Studies

This Subsection aims to distinguish garment design as a part of fashion studies, as well as to trace the renewed interest in garment design practice and materiality in fashion studies.

The study of garment design and construction has long been considered of narrower scope among the wider study of fashion. The term ‘fashion’ refers to garment, appearance and style; however, its study implies a broader context from production to consumption, and systems of meaning and signification (Rocamora and Smelik, 2015). Fashion can “be understood in the context of wider contemporary phenomena and human behaviour” (Hopkins, 2012, p.10).

Similar to other creative practices including art, fashion has been positioned and interpreted in the literature as a means of expressing social identity, political ideas and aesthetic taste (Breward, 2003). Therefore, fashion studies became a multidisciplinary field, including costume history, philosophy, sociology, anthropology and cultural, women’s and media studies (Rocamora and Smelik, 2015).

Breward (2003), Burman and Turbin (2002) note that from the nineteenth century until the early 1980s, before a wider resurgence, fashion knowledge only flourished within dedicated organisations, e.g. costume societies in Britain and America, and also in the history of fashion in British universities since the mid-1960s. “These contributed to a rich body of knowledge and detailed visual record of continual changes in garments and textiles.” (Burman and Turbin, 2002, pp.371-372) Breward (2003) highlights that, until recently, the expansion of fashion as a critical, historical study occurred outside creative and commercial practice and fashion design courses in educational institutions.

Analytical approaches to fashion emphasised language and semiotics in the 'linguistic turn' of the 1960s (Loschek, 2009; Rocamora and Smelik, 2015). Philosophers and semiologists, e.g. Roland Barthes, explored 'the code of fashion' (Loschek, 2009; Swindells and Almond, 2016). Rocamora and Smelik (2015) explain that this puts a central focus on textuality, extending the written text to images, music, architecture and fashion. Such overemphasis has been criticised in fashion studies. Entwistle (2000) debates this overemphasis on language and semiotic analysis, out-of-bounds of the action itself (Bourdieu, 1989 cited in Entwistle, 2000, pp.69-70), "effectively displaces the idea of embodiment and the individual and can give us no account of experience or agency" (Entwistle, 2000, p.70). Rocamora and Smelik (2015) note that similar sociological approaches understand fashion as an embodied practice in a social context: this transcends understanding fashion as a signifying system. Such approaches denote a renewed interest in the materiality of objects; this 'material turn' revives central issues for fashion studies, e.g. practice, embodiment, experience. Loschek (2009) denotes that at the turn of the twenty-first century, research demands an innovative approach, where theory is given access to practice. Recent views transition from an emphasis on human agency to an extended agency involving the non-human, including materials. As Woodward and Fisher (2014) state:

> Seeing fashion in terms of the relationship between a maker and garments or between a wearer and their clothes […] implies that either a designer or a wearer imparts their meanings or associations to the clothes. Agency emerges through these material/human assemblages. (p.8)

Likewise, Smelik (2018) remarks:

> New materialists work from a dynamic notion of life in which human bodies, fibres, fabrics, garments and technologies are inextricably entangled. (p.33)

Burman and Turbin (2002) explain that new analytical approaches to fashion arose as “a response to new studies of consumption” (p.2). For instance, the contemporary liquidity of post-modern culture and flexible identities and floating signifiers (Rocamora and Smelik, 2015). Fashion is arguably one of the most remarkable forms of global cultural fluidity (Calefato, 2018). Geczy and Karaminas (2018) state that, in the twenty-first century, dress became a means of self-expression, rather than as a signifier of status or profession; designers became ‘artists’, and fashion appeared in museums, e.g. Skin+Bones: parallel practices in fashion and architecture (Somerset House, 2008, London; The National Art Center; 2007, Tokyo and The Museum of Contemporary Art, 2006, Los Angeles); Extreme Beauty: the body transformed, (Met Museum, 2001, NYC, US); and the Intimate Architecture: Contemporary Clothing Design exhibition (MIT museum, 1982, Cambridge).

Over the last three decades, fashion has been researched and studied by practitioner-researchers (Valle Noronha, 2018), e.g. Finn (2014) and Huang (2012), demonstrating the increasing coming together of previously separate theory and practice. There has also been an increasing number of research projects and publications about smart materials and interactive design in wearable technology—e.g. Stead (2005), Kettley (2016), Quinn (2010), Colchester (2007) and Braddock Clarke and O'Mahony (2007).

Worth mentioning is the renewed interest in practice, materiality and the relationship between garment designers and their understanding of materials, and the growing body of research ‘through’ practice from practitioners’ perspectives.

2.4.2 A History of Garment Design and Construction

Historically, “garments have been created using various surfacing and structuring techniques to articulate the form in different ways” (Townsend and Goulding, 2011, p.303). Tailors emerged in the mid-twelfth century (Loschek, 2009). Garment design developed in the Renaissance, where padding techniques and corsets appeared—which influenced the silhouette (Hopkins, 2012). Hopkins (2012) and Breward (2003) state that, during the Renaissance, Burgundy and Spain were centres for fashion design and sartorial styles. It marked the use of whalebone, silk, brocades and damask. In the Baroque era, satin and taffetas were used instead of brocades and stiffed fabrics; also, the fashion design centre moved to Paris. The Rococo period showed advancements in textile milling and the use of lighter fabrics. Breward (2003) states that in the late eighteenth century, fashion emerged through commercialism as the “the self-consciously elite” became influenced by the “couture houses of Paris” (p.16) and Charles Worth, the founder of haute couture (Breward, 2003; Loschek, 2009).

Modern fashion began in the nineteenth century, when dress communicated position in society (Jackson and Shaw, 2008). Loschek (2009) remarks that clothing, previously classified as a handicraft product “made by tailors, seamstresses, embroiderers, ribbon weavers, trimmers and so forth” (pp.173-204), became a design product. DePauw (2017) notes that Howe Jr. invented the sewing machine in 1846, and Singer developed an affordable machine in 1851. Mass manufacture for clothes occurred in the nineteenth century for men as a result of the American Civil War and the need for large quantities of military uniforms. Measurements taken for soldiers’ uniforms caused a standardisation of sizes, leading the way for the ready-to-wear fashion industry. DePauw (2017) notes that the inclusion of women's fashion garments came later. Loschek (2009) specifies that a new ready to wear haute couture established itself in the 1960s. Such divisions, according to Loschek (2009), increased in the 1970s to encompass custom tailoring, luxury ready-made fashion, mass fashion and designer fashion.

Loschek (2009) and Koda (2001) emphasise that Modernism, Post-Modernism, Constructivism, Feminism, Structuralism and Deconstructivism movements that influenced art and architecture also influenced styles in garment design since 1975. Fashion was influenced by architecture (Hodge et al., 2006; Loschek, 2009) (see Section 2.5). Loschek (2009) argues that since the end of the twentieth century, fashion has been disintegrating into two extremes—over-individualised haute couture and characterless trademark fashion; rarely do the two overlap.

2.4.3 Garment Construction

Fischer (2009) remarks that knowledge and understanding of three-dimensional garment techniques from a two-dimensional design or pattern is vital for garment designers. The garment-making process involves important principles and methods (e.g. silhouettes, proportion, sizing, grading, taking body measurements, pattern blocks and pattern cutting), and the working concepts and notion of toile (prototype). Other methods of garment design are draping, padding and boning in corsetry and crinoline. Each of these methods plays a role in creating shape. Recent designs, over the last 15 years, show how fashion designers are influenced by technology (Loschek, 2009), and advances in digital tools in design and manufacturing (Computer-Aided Design [CAD] and Computer-Aided Manufacturing [CAM]).

Sculptural garments and accessories, e.g. ruffs, corsets and crinolines, were used historically to transform the proportions of the body (Koda, 2001). Legendary designers of the twentieth century, such as Poiret, Vionnet and Chanel, “promoted the body after it had been enclosed in structures” (Aldrich, 2008, p.5), and invented soft, easy-fitting clothes (Aldrich, 2008). A renewed interest in sculptural garments over the last forty years is more linked to artistic movements and conceptual design influences, and architecture (Hodge et al., 2006; Hopkins, 2012; Loschek, 2009; Robertson, 2009).

Avant-garde fashion designers experiment with garment construction methods to generate creative and controversial garments using cutting-edge tools and techniques. A unique approach towards handling textiles and constructing sculptural garments, which implies a high level of integration between design and specific material properties (Quinn, 2003). Leading fashion designers John Galliano, Yohji Yamamoto, Rei Kawakubo, Issey Miyake, Victor and Rolf, Thierry Mugler and Junya Watanabe (Figure 2-16), among others, have created contemporary sculptural garments (see Appendix 1, Section 1.2).

Besides the above literature and contextual review of garment design and construction, I conducted an extensive visual survey/review for sculptural garments and I organised current different historic and contemporary sculptural garments in different mind maps according to method and force applied on textile (see Appendix 1, Section 1.9, p.42 and p.45), which enabled me to define a number of generic methods in garment design that could have potential in spatial design, such as pattern cutting, draping and the use of boning.

Figure 2-16: Junya Watanabe, honeycomb ruff, "techno-couture", 2000-2001. Image source: Vogue (2000).

2.4.3.1 Pattern Cutting

Fashion researcher and academic Grayer Moore (2019) richly illustrates the history and development of pattern making for apparel, spanning over 600 years, although a lack of early records makes this history incomplete, as the work of apparel makers and craftspeople was regarded valueless or unworthy of archiving. Patterns were unnecessary, e.g. for tunics and Grecian garments. Garments were, mostly, determined by loom width, to be fashioned with virtually no waste.

Grayer Moore (2019) explains how economy-guided apparel developed in the pre-industrial context. Since weaving was a slow and laborious process, cantilever (protrusive) cutting and complex tailoring techniques were avoided, and precluded the need for pattern pieces. She clarifies literature resources that imply that pattern making existed in the fifteenth century. Gradual advancements, according to Grayer Moore (2019), in production and expansion of the textile trade increased the elaboration of fashionable dress during the mediaeval period. In Europe, novel approaches to apparel needed a plan for cutting shapes that followed and elaborated on the silhouette of the body (Grayer Moore, 2019). Grayer Moore (2019) describes ad hoc techniques, known as the ‘rock of eye’ or the ‘role of thump’ (techniques relying on hand-eye coordination and judgment), implemented throughout the eighteenth and early nineteenth centuries.

Drafting systems in pattern cutting largely replaced the more labour-intensive, less systematic practices which rely on body measurements. Aldrich (2008) remarks that adapting shapes from block patterns can be traced to the middle of nineteenth century (Figure 2-17). Grayer Moore (2019) states that, in parallel with publishing flourishing in this century, many rudimentary patterns were included in women’s magazines. This continued, with more pattern variety, through the twentieth and twenty-first centuries. CAD software and hardware were first used in the 1970s. In newer applications, the virtual textile is draped and fitted on a virtual body, where a surface-flattening algorithm is then applied to product flat patterns. Digital tools have been adapted to facilitate such methods digitally and achieve speed, accuracy and cost savings (Gray, 1998).

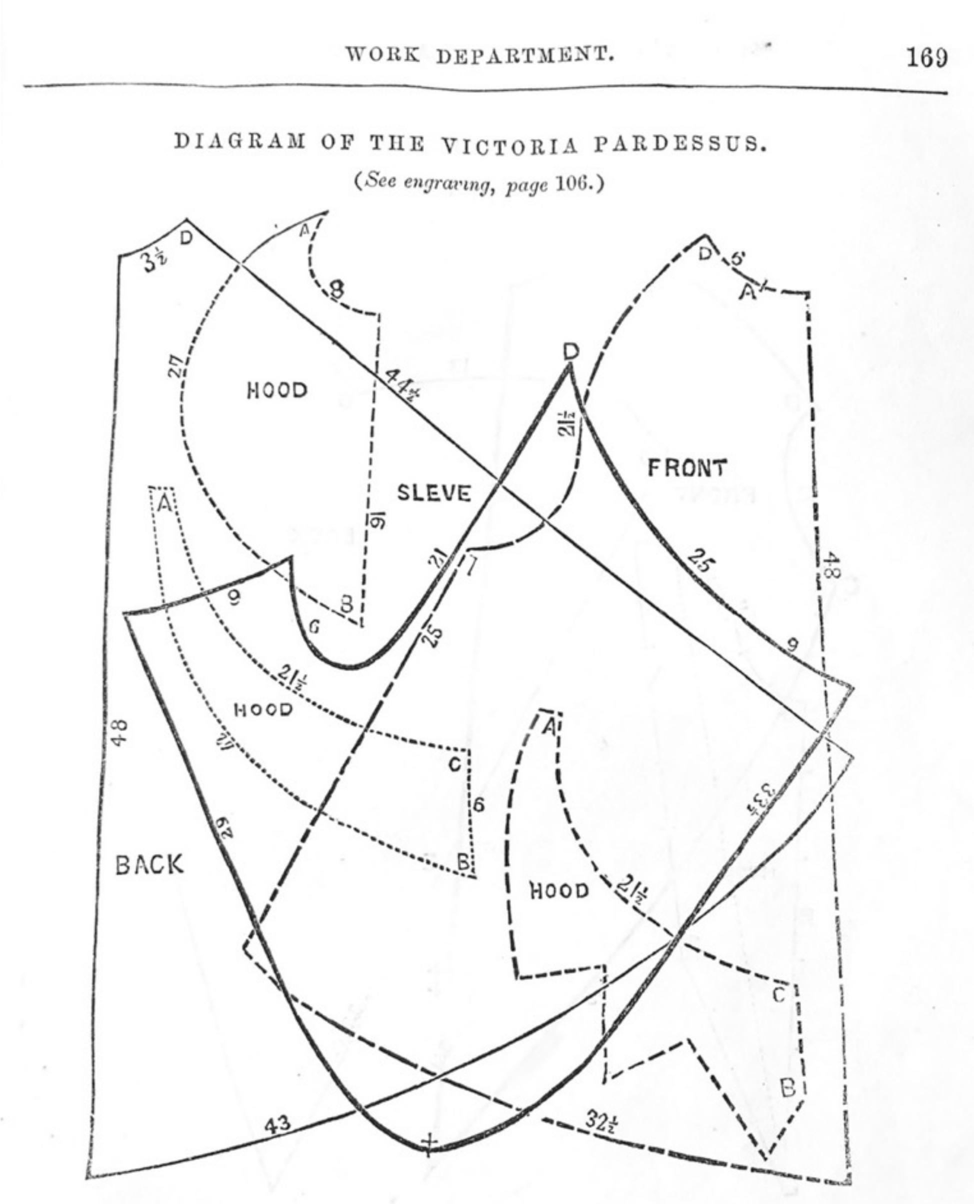

Figure 2-17: Pattern pieces in the nineteenth century. Image source: Moore (2019).

Currently, several books provide detailed information about using pattern cutting to construct garments: *Patterns of Fashion* 1, 2, 3 and 4 provide detailed information about constructing volume (Arnold, 1984, 1985; Arnold et al., 2018); the *Metric Pattern Cutting* series is a source for garment making, especially for educational purposes (Aldrich, 2008). Innovative and experiential pattern-cutting tutorials have been featured in *Pattern Magic* books 1-2-3 and *Pattern Magic* for stretch materials by Tomoko Nakamichi (Nakamichi, 2010, 2011, 2016, 2012). I found these four books inspiring and stimulating at the initial stage of 'through' practice experimentation in this research.

Different approaches can be used to extract garment patterns: drafting 2D patterns by a numerical system related to body measurements or by direct 3D modelling of fabric on a dress stand. Virtual models benefit from 3D body scanners to capture the body (Townsend and Goulding, 2011). Another method is the 'ripping off' of patterns from an existing garment, like historical garments (Grayer Moore, 2019). Several techniques can be used to manipulate patterns, e.g. darts, gathering, flaring, pleating (Aldrich, 2008) (see Appendix 1, Section 1.9, pp.38-41). Methods of pleating, steaming and ironing, tucking and origami contribute to fabric surface manipulation (see Appendix 1, Section 1.9, pp.43-44).. These methods can be used further to create a form, e.g. Issey Miyake's foldable origami garments; therefore, pattern cutting, as their foundation, is proposed as an essential method for 'through' practice investigations in this research.

2.4.3.2 Draping

The Greeks and Romans famously used draping to construct garments (Kemp-Gatterson and Stewart, 2009). Innovations in draping use can be seen in the designs of Madeleine Vionnet, the master of the bias cut, and the use of elaborate draping (Kemp-Gatterson and Stewart, 2009). Draping is creatively used by fashion designers like Alber Elbaz, who has an exceptional reputation following his various explorations of drape and detail (Palomo-Lovinski, 2010) (see Figure 2-18 and Appendix 1, Section 1.2, p. 12). Draping offers another method of creating a pattern through working with fabric on the dress stand, offering immediate results, but requires a level of manipulative skill to be acquired through apprenticeship or practice (Hopkins, 2012).

Figure 2-18: Dress, draping, Alber Elbaz, The Museum at FIT, 2011. Image source: Borrelli-Persson (2018).

2.4.3.3 Boning (Ribbing)

Boning/ribbing (Figure 2-19) and padding have been used in undergarment pieces to create volume in traditional costumes in Western cultures, e.g. corsets and bustles. Traditionally, metal, cane, wood, whalebone or horn were used in these pieces (Koda, 2001). More lightweight materials are now used for crinoline hoops: metal wires and fibreglass rods. Many contemporary designers have experimented with these pieces to create sculptural garments, such as Junya Watanabe, Victor and Rolf, and Rei Kawakubo (see Appendix 1, Section 1.2). Correlations between architectural structure and the boning/ribbing method were proposed for initial practical investigations in this research.

Figure 2-19: English petticoat bustle, 1871, the Metropolitan Museum of Art. Image source: Koda (2001, p.120).

2.5 Spatial and Garment Design: Parallel Practices and Recent Convergences

Section 2.3 addressed different manifestations of the relationship between spatial design and textiles, for instance, textile weaving as a metaphor for architecture, or textiles as an actual construction material in spatial design. However, the spatial design literature reviewed in that section does not differentiate between textile and garment design as two distinct areas. However, in this section, I recognise the relationship between spatial design and garment design as an interlinked, but distinct, area of research and practice from the relationship between spatial design and textiles.

In this section, I review the history of the relationship between spatial design (architecture and interiors) and garment design in literature. Most importantly, I review current research and practice on the borders between architecture, interiors and garment design.

2.5.1 Previous Disregard and Renewed Interest

Disciplinary discrimination occurred against garment design—comparable with attitudes to textiles (see Subsection 2.3.1)—as it was associated with crafts, manual efforts, the feminine and the ephemeral (Garcia, 2006b; Moore, 2019). Therefore, mainstream architectural history, theory and practice largely disregarded the relationship between architecture and garment design. Art historian Houze (2006) highlights an exception in Semper's writings about the origins of architecture and textiles "closely tied to his understanding of clothing and costume as used to transform the human body" (p.306). In the early twentieth century, Modernists rejected style, fashion and ornament for function (Hornbeck, 2010; Wigley, 1995). Paradoxically, architect and writer Wigley (1995) argues that white walls, the symbol of Modernism, are another form of dressing, garment and style.

Despite this history of frequent disregard, connections between fashion design and interior design can still be recognised: interiors and garments portray self-representation. By the nineteenth century, the interior was perceived as a theatrical background and extension of garments that shaped identity (Edwards, 2010). Berry (2018) remarks that the importance of interiors in fashion's written accounts and images occurred from 1860. Also, throughout the twentieth century to today, collaborations between couturiers and ensembliers (interior designers) have created fashion interiors and furniture for their branding and identity (Berry, 2018).

Architectural interest in garment design practice is observable in the last 40 years (Hodge, 2006). Braddock Clarke (2018) states that the advent of new materials and technologies is largely behind the recent convergence of textiles, fashion and architecture. Hodge (2006) additionally proposes that major fashion houses, such as Prada, have commissioned well-known architectural firms, such as the Office of Metropolitan Architecture (OMA), to design their retail spaces; plus, architects have increasingly abandoned hand drawing for digital drawing and modelling. Advances in digital resources have enabled architects to realise complex architectural forms. Fashion has provided inspiration regarding such formal complexity and, in particular, methods of construction and the manipulation of 2D cloth into 3D form.

The parallels between architecture and fashion appear in various exhibitions. First, Intimate Architecture (1982, in Braddock Clarke, 2018) showcased eight fashion designers' work linked to architectural form. Skin + Bones (2006, in Hodge, 2006) showcased the parallels between renowned architects and fashion designers between 1980–2006. Third, Block Party: Contemporary Craft Inspired By the Art of the Tailor, presented work by UK and international artists incorporating pattern cutting into their practice in innovative and unexpected ways beyond fashion garments (Sheffield Hallam University, 2012).

Since the year 2000, several art historians, critics and academic journals in architecture and textiles have published books and articles about the relation between architecture and fashion (Braddock Clarke, 2018; Hodge, 2006; Quinn, 2003). Hodge (2006) addressed the connections between architecture and fashion design in various topics, including historical precedents and stylistic parallels, the creative process and tectonic strategies and deconstruction approaches. The Architectural Design Journal (Architextiles, 2006) and the Textile Journal (Jefferies and Conroy, 2006), mentioned in Section 2.2, are other sources whereby the confluence is reflected, though they still contain only patchy references to fashion and garment design. Furthermore, the Body+Space conference (see Appendix 4, Section 4.6) showcased "new thinking and approaches that explore the diversity of human occupation, ranging from the garment to the city" (ADRI Middlesex University, 2014). I presented a paper about my research in this conference by bringing together spatial and garment design, noting that body and space are two huge multi-disciplinary topics inside which those of spatial and garment design can fit.

2.5.2 Engagements and Interpretations Between Fashion and Architecture in Research and Practice

Many architects, designers and artists experiment on the borders of these disciplines in different ways. Reviewing these engagements show that they include different forms :conceptual engagements; terminology borrowing/technique transferring; and reciprocal inspiration between buildings and garments— despite using solid materials in the case of spatial design interpretations.

The first form of engagement uses garment/clothing as a metaphor for spatial design. Garment as an envelope for architecture (Prada Skirt by architect Nigel Coates [2006; 2020]) or "clothing" for architecture (Casa da Música by textile and landscape designer Petra Blaisse, Portugal, 2005) (Weinthal, 2008). Likewise, visual artist Orta's work investigates boundaries between the body and architecture, and engages architecture and garment design to conceptually and metaphorically address global issues. The Gulf War and the resulting refugee crisis in the 1990s motivated Orta to employ her fashion design skills to express situations and crises (Quinn, 2003). Orta's projects ,such as Refuge Wear and Body Architecture, focused on the individual, the community and the collective (Quinn, 2003). In an interview in 2017, Orta stated that she used her knowledge as a designer to make patterns; those patterns became sculpture, then objects and wearables performed in different situations, which allowed the public to interrogate issues like refugees and homelessness (France 24 English, 2017). Orta's work is widely cited by literature addressing the relationship between fashion and architecture (Calefato, 2018; Braddock Clarke, 2018; Loschek, 2009).

The second forms of engagements are transferring tailoring techniques to spatial design and terminology borrowing. Quinn (2003) notes that architects derive techniques, such as pleating, pinning, cutting and draping, from dressmaking to design flexible, interactive, inflatable and portable buildings. Recent projects explore this in Computational Design (Simmonds et al., 2006). Also, the Fabric Formwork project—Mark West, the Centre for Architectural Structure and Technology, the University of Manitoba, Canada—experiments with transferring body-shaping corsetry techniques to textile casings as an intermediary material in moulding wet concrete into curvaceous silhouettes (Quinn, 2006). Fabric formwork is further explored in Milne et al. (2018), using techniques of pattern cutting, darts and seams. Work related to this thesis was presented by architect-academic Layden in the Body+Space conference (ADRI Middlesex University, 2014). He uses technique transferring through hands-on experiments by multidisciplinary teams (spatial and garment design practitioners). The main motivation was challenging orthogonal typologies traditionally associated with spatial design by exploring new design methodology "drawing on concepts from deconstruction, creative pattern cutting and the principle of function following form" (Layden, 2014).

Several differences can be recognised between these studies and my research. First, the use of textiles as a construction material or spatial designers' understanding of the potential of textiles and inherent properties are not central. Secondly, they focus on the transference outcomes rather than on an in-depth understanding of the process of integration and its nature.

A third and final form of engagement is that of interpretations from architecture into fashion, which Quinn (2003) describes as

> Their [fashion designers] use of structure and volume redistributes bodily proportions in a limpid, sculptural guise, yet the construction genius evident in garments that expand from flat forms into complex three-dimensional shapes recall architectural principles as precise as the buildings they are worn in. (Quinn, 2003, p.4)

Fashion designer Ying-Chia Huang's (2012) conducted doctoral research is another good example here. Her research explores architectural methods (architectural models and drawings) aimed at fashion designers and fashion design translators who want to avoid distortion or loss of design character during the process of transferring their 2D creative sketches into a 3D garment (Huang, 2012).

2.6 Conclusion

This chapter has reviewed theoretical (text-based) resources, historical and contextual materials related to the use of textiles in spatial and garment design. It reviewed how textiles have been used to construct different artefacts from garments, buildings and interiors to TSI spaces and art installations. It appropriately depicts a work of multidisciplinary research, and in it I focused on the following aspects of the literature.

Section 2.1, review, recognises the spectrum of perspectives and angles from which space can be studied and understood. Then it narrowed to how TSI space (the focus of this research) builds on an understanding of space essentially as being as much about materiality, structure and construction as spatial experience.

After grounding this study in space or spatial design, Section 2.2 showed that recent research and innovative textile use in spatial design follows two paths: 1) Increasingly, architects extend their approaches by inventing new materials through multidisciplinary teams and projects on the borders of architecture, textile design, textile science and interactive design. 2) Many architects are examining new applications for textiles and new innovations for different functions in spatial design. Although my interest in textiles was motivated by recent advancements and new textile innovations, I did not intend to invent a new type of textile in this research. Rather, I build on the current school of thought which explores how—rather than making new materials—material innovation occurs through transforming ways of material handling; by working with materials' inherent properties rather than in opposition to them. This school of thought acknowledges the wider context of materials' use beyond their architectural use and recognises the role of designers' skills and expertise in material use. Therefore, in this study, I undertook design and construction opportunities benefiting from textiles' inherent properties, such as their flexibility/malleability and ability to fold and drape, by observing how these are directed in a wider context, such as garment design practice.

In Section 2.3, I reviewed the relationship and different engagements between textiles and spatial design (architecture and interiors) in history, theory and practice, and I considered historical and contemporary practices of textile-based spatial construction. It highlighted the importance of skills transfer and textile advances in the development of textile-based structures. I reviewed recent research, which aims to advance textile use in spatial design by developing current approaches from a disciplinary point of view. In contrast, this research takes a different route to develop and transform textile use in spatial design by integration into garment design practice.

Section 2.4 examined garment design practice, which reflects a different approach to think about and direct textiles. Garment designers have historically handled textiles and accumulated a large body of collective experience over the long history of garment making. Fashion designers demonstrate a distinct understanding of the natural behaviour and properties of textiles, which has a wider application. Therefore, I reviewed garment design approaches (methods, processes and principles) to design and construct garments, and possible methods to integrate within spatial design.

Section 2.5 reviewed the history of the relationship between spatial and garment design, and showed the previous disregard of garment design and the renewed interest. It reviewed research and practice across the borders of spatial and garment design. It identifies three emerging cross-disciplinary engagements through theoretical literature, terminological borrowing and the reciprocal inspiration of forms. A scarce number of projects/studies focus on transferring tailoring techniques to architectural design, e.g. into computational design of tensile structures (Simmonds, Self and Bosia, 2006), or as an intermedial material for concrete formwork (Milne, Pedreschi and Richardson, 2018; West, 2016); also, to challenge orthogonal typologies traditionally associated with spatial design by exploring new design methodology (Layden, 2014). In contrast to my own research, in these identified engagements of textile use as a construction material, spatial designers' understandings of textiles' potential and inherent properties are not central issues. Furthermore, these engagements focus on the product and outcomes of transference/integration between garment and spatial design. It was difficult to locate studies addressing integration across garment and spatial design that simultaneously recognise the nature of this integration and aim to understand its process concerning the integration of practice.

This research features the use of textiles as a shared phenomenon and an interface between the currently parallel practices of garment and textile-based spatial design. From an interdisciplinary perspective, each of these practices reflects different disciplinary insights into textiles’ potential and their use.

This contextual review suggested that there are differences in how garment designers handle and manipulate fabric compared to spatial designers. To extract elements that cause these differentiations is a mission beyond reading and theoretical knowledge; finding how integration occurs in practice requires physical engagement with material through practice. Building on this, and on gaps identified in current theory and practice, I aimed to examine a different path to explore the further potential of textiles and their properties beyond their architectural context. I looked at integrating garment design, which follows a distinct approach to constructing three-dimensional forms.

Chapter 3 Fashioning Space: Shaping Methodology 'Through' Practice and Interdisciplinarity

Chapter 2, 2, Section 2.5 studied different engagements between garment design, interiors, architecture and art, including theoretical writings, terminological borrowing and the reciprocal inspiration of forms. There are a limited number of projects/studies that focus on transferring tailoring techniques to spatial design. But it was hard to find studies that address integration between garment and spatial design that focus on the use of textiles as a construction material, spatial designers' understanding of the potential of textiles and their inherent properties, and simultaneously recognise the nature of involved integration and study its process— rather than focusing on the outcomes only.

The current chapter reflects on interdisciplinarity and research 'through' practice. The focus is to create a methodological framework that identifies the researcher's position, and appropriate strategies and methods to answer the research questions.

The contextual review indicates how the gaps identified in the existing research emphasise the importance of this research project mainly within the context of interdisciplinary research and research through practice and design thinking in spatial design.

In this research, my approach unfolded through the evolution of the research question and a process of interdisciplinary experiential activities. The evolution of research questions in practice-led research is not uncommon (Gray and Malins, 2004). Creswell describes an iterative process of qualitative research, where research questions tend to be open-ended and are often reshaped to reflect evolving understandings (Groat and Wang, 2013). Furthermore, method in practice-led research is often characterised as emergent and responsive; it develops and "unfolds from the practitioner's interaction with the research question and context and the research is grounded" (Gray and Malins, p.72).

My research focus has evolved from focusing on 'what' (of space and method/practice 'transference') to focusing on 'how': how an integration of practice may happen; how this may transform current practices in spatial design; and 'how' integration is triggered, initiated and/or advanced in a nuanced manner. The research, especially in later analysis stages, started to focus on designers (including myself as a designer-researcher) and their actions (practices), with the assumption that these actions are meaningful and can be interpreted and understood (Crouch and Pearce, 2012).

This research aims to achieve *integration* between spatial and garment design practices as a strategy and stimulus to transform the way textiles and their inherent properties can be used in Temporary Soft Interior (TSI) space design and fabrication—and to *study* how this process may happen.

Chapter 3 will map interdisciplinary research 'through' practice as a dominant research strategy, which encompasses experiential design, making and learning activities, first in a pilot stage and then in a design project for a TSI space. These investigations use digital tools, virtual and physical materials and hands-on approaches. Through this strategy, an interdisciplinary research framework is applied to the context of research 'through' practice. This chapter also illustrates how a case study of the same TSI space design project, undertaken by other designers (design students), augments this research 'through' practice strategy.

Before introducing the methodological framework, the development of practice-led research and research 'through' practice in art and design and architecture (ADA)[7] will be introduced, followed by how my enquiry and methodology evolved.

3.1 A Brief Overview: The Development of Research in Art, Design and Architecture (ADA), Practice-Led Research and Research 'Through' Practice

According to an AHRC (2007) report, despite their long history, art and design (though, not architecture) are considered as emergent academic disciplines (Rust, et al., 2007). As Gray and Malins (2004) explain, science (for over 300 years) and social science (for 160 years) are well-established research areas compared to art and design, with a range of validated methods, depending on paradigm and situation.

Reviewing previous research and literature about art and design and architecture research in the UK shows that methods for practice-led research and research 'through' practice itself are still developing. For instance, in March 2018, the Journal of Interior Design dedicated a special issue to practice-based research (Preston, 2018) in which Valle Noronha (2018, p.7) states, "practice-based research in fashion is still in its infancy", noting that "the first internationally recognised academic journal dedicated to the field (Fashion Practice) was launched in 2009".

To understand this approach, let us review how research in art and design and architecture (ADA) has been conducted by other academics—historians, educationalists, sociologists, and psychologists (Gray and Malins, 2004)—according to their traditions. Niedderer (2013) states that even when academics in art and design conduct research, they do so with established traditions in mind. For instance, Luck (2019) emphasises that, with few exceptions, research methods originate in other disciplines, such as physics,

[7] An AHRC (2007) review brought art, design and architecture together in practice-led research and considers, despite differences between ADA practices, learning and scholarship is situated in a professional practice setting (Rust, et al., 2007, p.10).

philosophy, history, geography and psychology, and are then applied to architectural design research.

Since the 1990s, new perspectives have proliferated, although some ideas have been around since the 1960s and 1970s (Rust, et al., 2007). Practitioners (designers and artists) have become increasingly engaged in research (Nimkulrat, 2012). In the UK, since 1992, research in art and design has changed dramatically (Luck, 2019; Niedderer, 2013; Rust, et al., 2007; Rendell, 2004); especially with the extensive debate on the nature of 'research' (Gray and Malins, 2004). This change happened for several reasons: art and design incorporated within universities, enabling doctoral studies for practitioners (Durling, Friedman and Gutherson 2002 cited in Niedderer, 2013); funding for academic research in ADA (HEFCE, 2008); and the REF/RAE's[8] recognition of other forms of contribution to research knowledge embracing:

> the invention and generation of ideas, images, performances, artefacts including design, where these lead to new or substantially improved insights; and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes, including design and construction (HEFCE, 2008, p.5).

Since then, scholars have called for more suitable approaches and for methodological innovations (Cross, 2001, 2006; Gray and Malins, 2004; Manning, 2016; Niedderer, 2013). For instance, Manning (2016, p.26), asks "how [art] practices produce knowledge, and whether those forms of knowledge can engagingly be captured within the strictures of methodological ordering". Simmons (2018) argues, referencing Manning (2016), that if new knowledge forms are to emerge, 'official' methods and traditional subject borders must be escaped.

[8] Research Assessment Exercise RAE was replaced by Research Excellence Framework (REF) in 2014.

The call for a new approach can also be traced in Frayling's (1993) paper, widely referenced by scholars of practice-led research in art and, to a lesser degree, design (Luck, 2019; Postiglione, 2013; Rendell, 2004; Rust et al., 2007). In this paper, Frayling adapts Herbert Read's[9] 'Education Through Art' model, presenting a three-way model of research 'into', 'through' and 'for' practice (Frayling, 1993. p.5). Similarly, design research highlights a three-way model attributable to Bruce Archer (1995) "who, during his post at the Royal College of Art from the 1960s, coined the phrase: 'research about design, research through design and research for the purpose of design" (Pedgley and Wormald, 2007, p.72).

Pedgley and Wormald (2007) and Niedderer (2013) argue for a more suitable term such as research 'through' designing, explicitly to denote research where practitioner-researchers engage in her/his own design/work through a research problem. Likewise, Nelson (2013) states, "practitioner-researchers do not merely 'think' their way through or out of a problem, but rather they 'practice' to a resolution" (pp.10–11).

Rendell (2004, p.144) argues this process functions through "generative or propositional modes producing work" to "then be reflected upon, along the lines of Donald Schön's 'reflection in [and on] action' (Schon, 1987)". Gray and Malins (2004, p.32) describe how research 'through' practice operates, and how researcher-practitioners combine "creative action and critical reflection […] in a kind of Yin-Yang dynamic". They highlight that practitioners "learn by doing, and 'know' by doing and experiencing" (p.32). Similarly, this research process involves data 'created', rather than data 'collected' as they might be in the social sciences.

[9] Read (1958) criticises the traditional education system and demands a new system embracing the role of various artistic expressions and experiences in education, such as design, crafts, music and poetry.

Coming from a design background, I conducted this project based on the awareness and recognition of a designer-researcher's role. As Owain Pedgley states:

> You don't need to design in order to deliver high-quality research, for example, into other people's designing, into the efficiency and desirability of products, or into the effectiveness of newly devised design guidelines. But where's the continuity, sense, satisfaction, or empowerment in that for a design graduate? (Rust et al. 2007, p.5)

3.2 Methodological Framework

This section will provide a brief illustration of this research's two strategies and the individual methods used/developed. Sections 3.3 and 3.4 will illustrate these in depth, with detailed discussion.

In its broadest sense, "methodology refers to the philosophy and framework that are fundamentally related to the entire process of research" (Opoku, Ahmed, Akotia, 2016, p.33). It guides the research project from its conceptualisation to data gathering, analysis and final presentation, and "offer[s] the broader principles that underpin particular methods" (Crouch and Pearce, 2012, p.63). Kaplan (2017) identifies the aim of methodology as being to describe and analyse methods, reveal their limitations and resources, illustrating their assumptions and consequences. It leads to the appropriate choice of methods, and further development and application of new methods (Friedman, 2002 cited in Gray and Malins, 2004). Methods, however, are the specific techniques of data collection and analysis (Creswell, 2003).

In art ,design and architecture (ADA) research, possible research areas and topics are vast. The challenge for methodology is that the multidisciplinary nature of these areas begets various research topics and possible research approaches. Many authors follow Kaplan's lead to focus on the research process, or what they term as the "mid-range"[10] aspects of methodology, which can be shared between a variety of research topics and fields (Groat and Wang, 2013; Gray and Malins, 2004; Kaplan, 2017; Postiglione, 2013).

Groat and Wang (2013), in their *Architectural Research Methods* book, propose adapting the terms 'strategy' and 'tactics'. Strategy denotes the overall research design; tactics refers to specific methods, such as data collection and analysis. Furthermore, they highlight that, in research design, there is "a set of steps and procedures that may range from being highly prescribed to being emergent as the research proceeds" (p.11). Hence, the term 'research design/strategy' includes the plan of action that links philosophical assumptions to specific methods (Creswell, 2003).

The general methodological framework in this research is focused on the *research process,* linking different methods to practice as a way of knowing. On the epistemology of practice, Schon (1983) highlights how professionals rely on 'knowing-in-action'. He advocates an epistemology based on reflection-in-action, originating in Kolb's theories of experiential learning.[11] Practitioners' improvisatory responses to challenges and problems improve via a continuous process of learning through experience, rather than, for example, through 'propositional knowledge'/'knowing that' (Schon, 1983).

In contrast to scientific or conventional enquiry, which implies a separation between theory and practice, this research is conducted 'through' reflective practice. It recognises that "situations of practice are not "problems to be solved, but problematic situations characterised by uncertainty, disorder and

[10] Grout and Wang (2013) follow Kaplan's lead in his classic book, The Conduct of Inquiry, by using the term methodology for "mid-range" aspects of the research process that are common to a range of disciplines. This means processes that are more general than interviewing techniques, more specific than epistemology which involves assumptions about the nature of knowledge or being.

[11] The concept of reflective practice is much older and from works related to human learning and development. For instance, David Kolb's (1994) theory of experiential learning which relies on John Dewey's (1904, 1933) theories of reflective practice and experience.

indeterminacy" (Schon, 1983, p.25). Schon highlights the reflection-in-action role to reshape the relationship between research and practice. He explains:

> …when someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories of established theory and technique, but constructs a new theory of the unique case. (1983, p.85)

In this research, I considered Schon's concept of reflection-in and -on-action, and the importance of experiential learning. Experiential learning occurs throughout a cycle in which four stages can be recognised: (1) learning from 'concrete experience' via (2) reflection, and (3) abstraction/conceptualisation, which leads to (4) experimental action (Kolb and Fry, 1975 cited in Lawson and Dorset, 2009, pp.282–283).

As a practitioner-researcher, my practice was not arbitrary, but directed towards a purpose: achieving and understanding the integration of practice to transform the use and understanding the potential of textiles' inherent properties in spatial design. However, individual practice activities were responsive, open-ended and not planned ahead (not in the sense of a traditional research process). This open-ended practice of experiential learning, and reflection-in and on-action (Rust et.al., 2007), became a driver for subsequent steps. In this research, *practice* created specific settings and contexts to trigger and study the integration process and its outcomes in depth. Produced objects and designs were not sought as a final outcome; rather, as Rust et al. (2007) state, "the knowledge associated with the artefact is more significant than the artefact itself" (p.12).

In this research, I built on Groat and Wang's (2013) use of 'strategy' for research design and 'technique' for research method. Moreover, this research built on the interdisciplinary research process outlined by Repko (2008): integrating disciplinary insights as a way of knowing and producing new knowledge. Therefore, I composed an interdisciplinary 'through' practice strategy, which implemented different experiential making, designing and learning activities/experiments, first in a piloting stage, then in a TSI space design project stage to the interdisciplinary research process (Repko, 200).

Groat and Wang (2013) also propose a ‘dominant-less dominant’ research strategy, which involves a main design framework where a distinct research design is attached (the ‘less dominant’ strategy). In this model, one advantage is that the emphasis is on the main approach and the overall coherence. A disadvantage is that the “complementary strengths of [the] less dominant design [are] not fully realised” (Groat and Wang, 2013, p.448).

This interdisciplinary ‘through’ practice strategy (the dominant research strategy) was augmented by research ‘into’ practice via a case study of an experiential TSI space design project undertaken by other designers (design students). As will be explained in Section 3.4, this case study was an emergent opportunity, which had the potential to provide crucial insights into this research. Data collected from the case study—through participant observation, case documentation/field notes and two follow-up interviews—were compared to data generated and collected from my research ‘through practice’ approach (Figure 3-1).

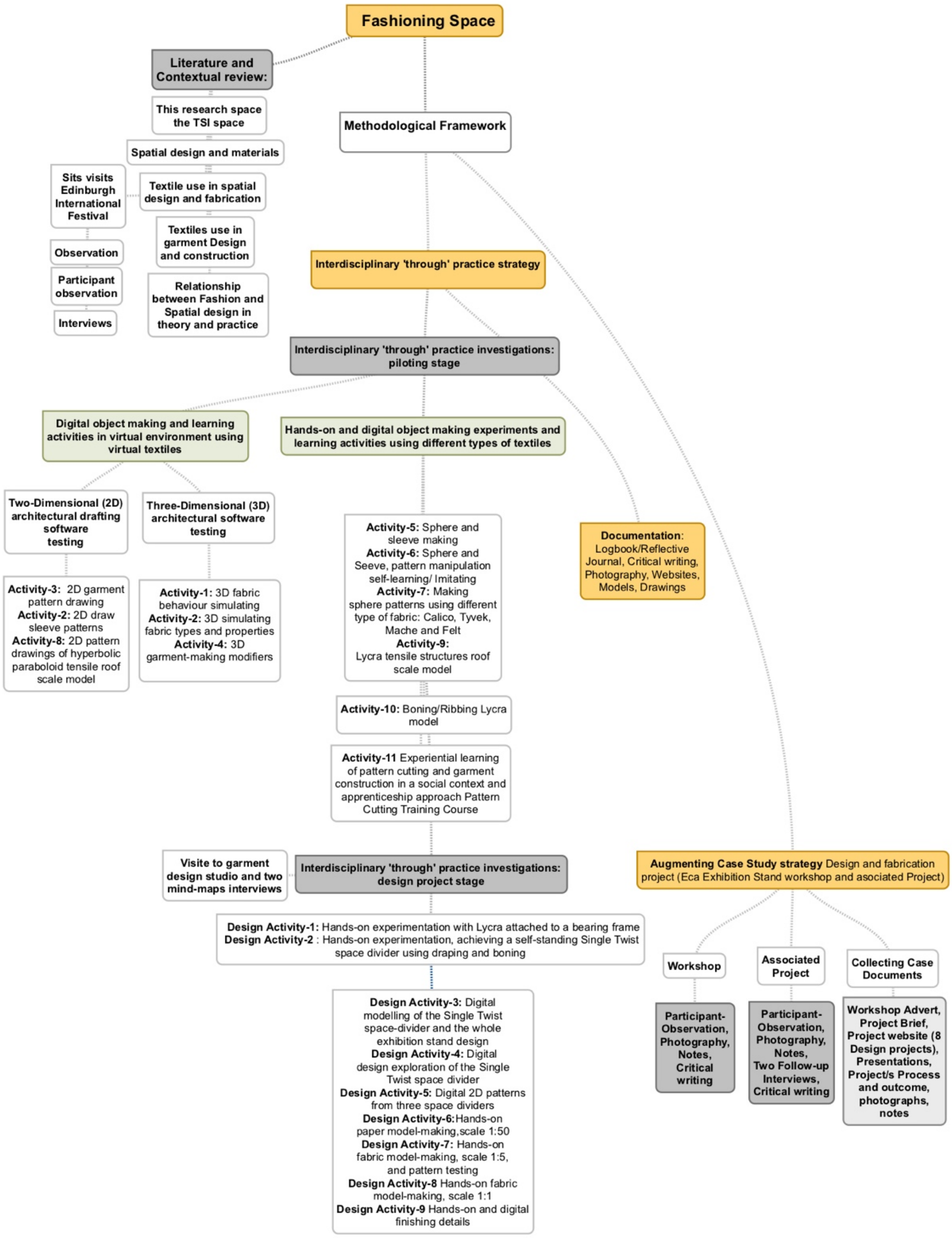

Figure 3-1: Diagram by author. Overview of Fashioning Space dominant-less/dominant research strategies and methods.

3.3 Composing an Interdisciplinary 'Through' Practice Research Strategy

This section firstly identifies research 'through' practitioners' practices characteristics, main requirements and concepts concerning reflection-in-action, and designers' ways of knowing and involved knowledge types. Secondly, it will define interdisciplinary research and its distinct ways of creating new knowledge in comparison to disciplinary research. Thirdly, it will illustrate how an interdisciplinary research framework developed by Repko (2008) was applied in the context of research 'through' practice in this research. It will show how an interdisciplinary 'through' practice research strategy was composed (as the main research strategy) and why specific methods, sensitive to the nuanced differences between spatial and garment design, were implemented in this strategy.

3.3.1 Research 'Through' Practice in This Research

This Subsection will show how research 'through' practice was employed in the dominant research strategy (interdisciplinary 'through' practice research strategy) and how its requirements were met in detail.

A research 'through' practice approach was required to allow us to imagine and create new realities in which integration of spatial and garment design can be achieved and studied. As Archer (1995) states, endorsing the irreplaceable role of research 'through' practice:

> There are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculate, explore, embody or test it. (p.11)

Likewise, practice was a crucial mode of inquiry to engage all types of knowledge involved; namely, tacit and practical/experiential knowledge, which are central at this level of integration which goes beyond aspects related to explicit knowledge (Niedderer, 2013).

Niedderer (2013) outlines how practice can serve two directions: *synthetic*, exploring the combination of different parameters to generate *new* concepts, *insights and possibilities*; and *analytic*, to better understand a *given* concept. In this study, *practice* was used to synthesise/integrate spatial and garment design insights into the use of textiles; likewise, it was used to analyse and understand how this integration may occur.

However, as Gray and Malins (2004, p.104) indicate, practice "research for higher degrees, [is] distinct from 'practice as usual' in its use of practice within an academic framework, which is accessible, transparent and transferable (in principle if not specifics)". Accessibility and transparency were maintained in this research through different stages via different documentation types, such as a digital reflective journal and photography (more details in Subsection 3.4.5.2). Regarding transferability, the practice research strategies and methods set down in this thesis, which ultimately led to integration, are designed to be usable by others.

Doloughan (2002) argues that the difference between researcher-practitioner in opposition to practitioner is that the researcher must "communicate the results of a process of enquiry, whether this enquiry be purely theoretical or [… has] practical applications" (p.59). Research communication and peer review occurred through presentations in the research-in-progress seminars series at Edinburgh College of Art (ECA) in 2011–2013; national and international peers at two conferences (PPOP, 2012, Glasgow, and Body+Space, 2014, London; see Appendix 4, Section 4.6); an interdisciplinary creative MScR course at the University of Edinburgh (UoE) in 2014; RAFT[12] in the ArcInTex April Conference Talk in 2018; and the

[12] A research network at UoE aiming to support and explore the changing identity of creative practices within art and design practices.

Interiors Research Themes group at Edinburgh College in 2019. As well as communicating findings, dissemination facilitated reflection on practice and process, which was crucial for analysis and theorising.

Pedgley (2007) emphasises that the designer-researcher, who is skilled in design, needs to combine the roles of a scholar and a designer: "something that is known to be intellectually challenging" (Archer, 2004; Hales,1987a cited in Pedgley, 2007, p.463). Pedgley and Wormald (2007) also stress,

> Candidates need not abandon their hard-won design skills and design portfolio in the process. The position that designing and researching are mutually incompatible no longer carries weight, so long as a carefully conceived research methodology is adopted. (p.58)

One significant ability of designers is their ability to envision and visualise new potential (Lawson and Dorset, 2009). They understand how to articulate and test these 'potentials' through making. Take this example about the potential of new materials in musical instrument design:

> Technologists may speculate that new materials may be useful for musical instruments but they need the designer to explore how that possibility will work in practice before they can begin to understand it. (Rust et al., 2007, p.57)

Similarly, in my research, I was exploring new processes and practices. I used my imagination and design skills to explore the potential of textiles in TSI spaces through interdisciplinary practice. Noting, design and creation are characterised not by propositional knowledge, but by being experiential and procedural (Niedderer, 2013). Therefore, "designing in the context of research can be used to access this type of knowledge [experiential, practical and tacit] inherent in design methods, procedures, materials artefacts, and concepts which would not otherwise be available" (Niedderer, 2013, p.6).

Gray and Malins (2004) and Pedgley (2007) assert that engaging in research makes converting tacit knowledge into explicit knowledge mandatory—a conversion facilitated through *reflective* practice and, as Nelson (2013, p.20) suggests, a process of “dynamic movement from the closeness of subjectivity to a greater distance, if not quite achieving objectivity as traditionally conceived”. He recommends, to advance and better recognise practitioner-researchers’ tacit understandings, methods of recognising and articulating should always be sought, even if it is impossible to convert tacit knowledge to explicit knowledge thoroughly (Nelson, 2013).

In this research, my aim was to achieve integration of practice, to understand and interpret this process, and externalise it to others. As a researcher-practitioner, I was the main instrument to generate, aggregate and accumulate various data types related to different forms of knowledge (tacit and explicit). As a researcher-practitioner, my processes and outcomes (including objects, insights and understandings) were rich data sources.

Taking a researcher-practitioner role implies a high potential of having an ‘insider’ view (especially at the time of generating and collecting data—a more distanced view could be achieved at later stages of analysis and reflection). Shortcomings could include difficulty in adopting an open-minded approach and managing preconceptions (Gray and Malins, 2004). Shortcomings were managed by communicating this research with peers on many occasions— as mentioned earlier. Furthermore, undertaking a case study of others’ practice and comparisons to my own practice helped to develop intersubjective views.[13] in addition, interdisciplinary traits and competencies I developed in this research, such as perspective-taking and empathy, helped me to take more open-minded views, especially in detecting disciplinary biases and pre-assumptions.

[13] “ Traditional qualitative research assume that (a) knowledge is not objective Truth but is produced intersubjectivity” (Marshall, and Rossman,2016, p. 22).

3.3.2 Knowledge Creation in Interdisciplinary Research Versus Disciplinary Research

Disciplinary-specific knowledge is produced, and the divisions maintained, in academic institutions by disciplinary researchers; but while disciplines "dictate what you can know and what you can do with that knowledge" (Lyall et al., 2011, p.19), Kaplan (2017) argues that pursuing knowledge has no borderlines; and, as Wilson (2014) notes, professionally trained disciplinary knowers have a short history in comparison to the lengthy history of knowledge itself. Wagner et al. (2011) highlight how the growth of academies in the nineteenth and twentieth centuries marked a growing distinction between disciplines and isolated their members from one another.

Repko (2008) indicates, according to Newell and Green (1982), that many aspects distinguish disciplines: including the questions they ask; their perspectives or world views; and the methods they use. Disciplines can be represented by university departments, where clusters of related disciplines form larger units, such as colleges of liberal arts or social sciences (Repko, 2008). Repko also notes that disciplines examine disciplinary knowledge (in books, databases and conferences) and departments organise the production and conveyance of knowledge to the next generation.

We can consider interior design and garment design as disciplines in their own right, as well as subdisciplines of design. In this study, textile use as a construction material to design and construct different artefacts (garments, interior spaces, buildings) is seen as a shared phenomenon filtered through the disciplinary lens[14] (Repko, 2008) of architecture, interior and garment design.

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[14] In addition to Repko's metaphor of disciplines as lenses, Choi and Richards (2017) list several metaphors, developed by researchers: perceiving disciplines as nations, tiles, languages and cartels.

Literature about interdisciplinarity emerged in 1930 and reached a peak in the 1970s–1980s (Lyall et al., 2011; Repko, 2008). Many definitions of ‘interdisciplinary’ have formed, while new ones emerge (Barry and Born, 2013; Choi and Richards, 2017; Repko, 2008; Wagner et al., 2011). Repko (2008) proposes an integrated definition featuring four core concepts: disciplines, process, integration and a more comprehensive understanding.

> Interdisciplinary studies is a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline and draws on disciplinary perspectives and integrates their insights to produce a more comprehensive understanding or cognitive advancement. (Repko, 2008, p.12)

Additionally, many studies (Lyall et al., 2011; Repko, 2008; Wagner et al., 2011) distinguish interdisciplinary research from other types, such as multidisciplinary[15] and transdisciplinary.[16] What differentiates interdisciplinary research processes is that “integration is at the very core of interdisciplinary activity, whereas it is not the core of disciplinary activity” (Repko, 2008, p.138). Thus, in comparison to the disciplinary ways, interdisciplinary research produces knowledge by integrating insights. Repko (2008) explains that disciplinary insight/understanding—not to be confused with perspective[17]/outlook—is produced by a discipline’s experts, about a problem or a class of problems. Similarly, this research aims to integrate garment and

[15] That places insights from two/more disciplines in parallel without creating a comprehensive/interdisciplinary understanding. Repko (2008) uses two metaphors to illustrate the difference: fruit salad (multidisciplinary research) and smoothies (interdisciplinary research). Wagner et al. (2011) states multidisciplinary is the sum of parts where disciplinary elements retain their original identity. Furthermore, Lyall et al. (2011, p.14) state multidisciplinary work is self-contained: “The final report from a multidisciplinary project is likely to consist of sections, each written from the perspective of a particular discipline, with a conclusion section that merely summarizes these contributions without attempting to integrate outcomes across disciplines”.

[16] Transdisciplinary research, such as women and gender studies, differs from interdisciplinary by transcending the limited scope of disciplinary world views (Wagner et al., 2011) and implies collaborations with parties outside disciplines (Repko, 2008).

[17] Disciplinary perspective, which shouldn’t be confused with disciplinary insight, refers to the “ensemble of discipline’s defining elements that include phenomena, assumptions, epistemology, concepts, theory, and methods” (Repko, 2008, p.58).

spatial design insights about the use of textiles in TSI space design and fabrication.

3.3.3 Adopting Interdisciplinary Research Models into Research ‘Through’ Practice

This Subsection illustrates in detail how an interdisciplinary research framework (Repko, 2008) was adopted into research ‘through’ practice and how and why specific practice-originated research methods/techniques were implemented.

This research speculates on the integration of practice between spatial and garment design practices as a way of knowing and of producing new knowledge, *and* as a strategy for transformation and innovation (Repko, 2008). Nelson (2013) and Simpson et al. (2010) highlight that interdisciplinarity stimulates creativity through de-familiarisation, offering the opportunity to step outside disciplines and their world views.

Calls for interdisciplinary conversations and research approaches in disciplines involving creative practice can be traced, for instance, in Lucas (2016), who recommends exploring methods and theories with others who are interested in the researched topic, to examine it using an alternative focus. Further, Rendell (2004) calls for interdisciplinarity to create connections between research and practice beyond established connections, such as Frayling’s ‘through’ practice model (Frayling,1993). By adopting an interdisciplinary research framework, to research incorporating practice, this research adds a new dimension to disciplinary knowledge creation ‘through’ practice and transcends them.

Repko (2008) proposes an overarching interdisciplinary process model which draws on suitable disciplinary methods to conduct research, building on other authors; notably, Julie Thompson Klein and William H. Newell (Repko, 2006). Repko (2008) is one of the first books in the field (Szostak, 2006).

Repko (2008) asserts that his two-stage model (illustrated in Figure 3-2) is flexible and applicable to different research situations: a) drawing on disciplinary insights; and b) integrating insights towards an interdisciplinary understanding and test of the problem. It is worth noting that stages are not necessarily conducted in sequential order, as this process is iterative. Repko (2012) states the pointlessness of strict guidance for an interdisciplinary research process, as this might remove creativity and align procedures with traditional disciplinary research, of which it should be critical. Likewise, Mackey (2002) emphasises the importance of intuition, while Welch IV (2007) detects the tension between the need for rigour in opposition to open-mindedness required throughout this process.

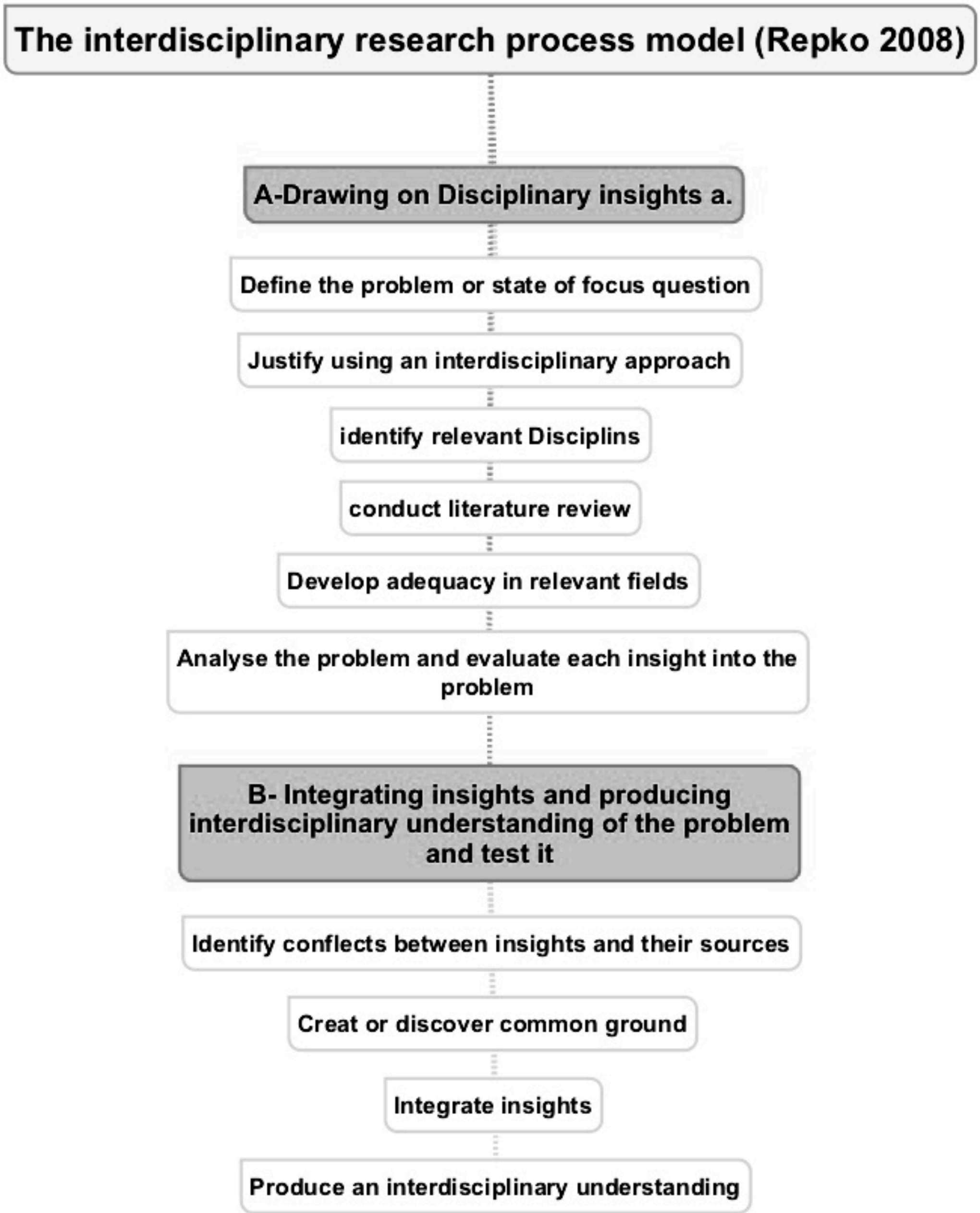

Figure 3-2: Diagram by author, based on Repko's (2008) integrated model of the interdisciplinary research process.

This research adapts Repko's model to the context of research 'through' practice in spatial and garment design. In the first stage (A in Figure 3-2), Repko (2008) emphasises that researchers must develop a level of adequacy when undertaking an interdisciplinary research to be able to construct an understanding of concepts and ideas within the fields in question:

> By *adequacy* is meant knowing enough about the discipline to have a basic understanding of how it approaches the problem and how it illuminates and characterises the problem. (p.189)

Repko (2008) highlights, conversely to disciplinary researchers who develop mastery, interdisciplinarians focus on the mission at hand; "comprehending enough of the discipline to decide which of its defining elements bear on the problem most directly" (p.189). This notion is also highlighted by Nelson (2013) in research approaches encompassing research as practice:

> …while it is not possible for a PaR [Practice as Research] student to equal the specialist in all disciplines drawn upon, the shortfall does not amount to a lack of thoroughness. Rigour in this aspect of PaR lies elsewhere in syncretism, not in depth-mining. In addition to challenging the student, a PaR approach does indeed challenge supervisors and assessors. As Elkins remarks, '[t]he specialist no longer acts as a specialist in her own field', and it is the case that supervisors need to develop an approach different from the traditional. (p.34)

When Repko (2008) recommends building adequacy he refers to activities involving reading relevant literature, attending seminars, evaluating insights and asking experts. In research 'through' practice, practitioner-researchers implement disciplinary practice as a preliminary research component. Namely, research methods employ approaches and methods, such as design and making, and the involved techniques of sketching, drawing, model making and so on.

Therefore, to build adequacy in my fields of practice, I interacted with students and experts in garment design, and learned the core methods, concepts and processes of their practice, for instance, undertaking a pattern-cutting course and consulting fashion tutors, technicians and postgraduate students. Regarding textile-based architecture and TSI space design, as mentioned in Chapter 2, I visited several textile-based temporary spaces at the Edinburgh International Festival. I participated in their installation, and interviewed and had discussions with designers and fabrication managers (see Appendix 2). Also, I attempted to build scale models to understand the main principles of tensile fabric architecture in practice.

In Stage B (Figure 3-2), interdisciplinary studies produce new areas of knowledge through an operation called ‘integration’ (Repko, 2008). Repko’s (2008) model is based on cognitive psychology (Choi and Richards, 2017), in which he notes that integration is a process, “an activity of critically evaluating and creatively combining of ideas and knowledge to form a new whole or cognitive advancement” (p.116). He explains that integration encompasses several steps: identifying conflicts in insights, creating or finding their common ground, integrating insights and producing interdisciplinary understanding (illustrated in Figure 3-3). Many sources agree that interdisciplinary knowledge is produced through a process of integration (e.g. see Choi and Richards, 2017; Lyall et al., 2011; Repko, 2008; Repko, Szostak and Buchberger, 2017; Wagner et al., 2011).

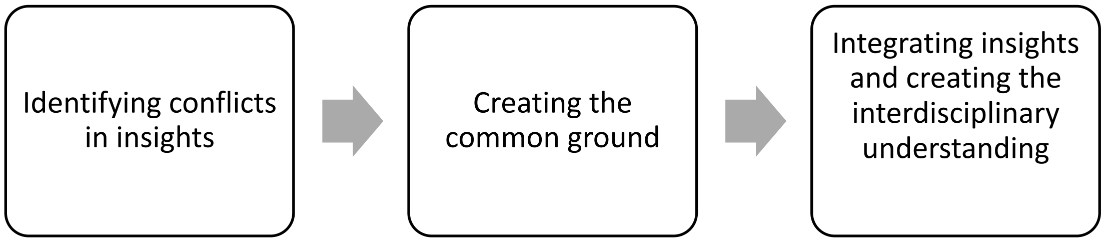

Figure 3-3: Diagram by author, based on Repko’s (2008) integration process.

The literature highlights that, during this interactive process, researchers should consider and anticipate tensions and issues related to their research position (Barry and Weszkalnys, 2013). Thus, research methods based on disciplinary practice may encounter nuanced differences, manifested, for example, in the dissimilarities between spatial and garment design practices. Several of these differences—mainly about experiential/practical knowledge related to involvement with materials—were revealed and integrated by choosing various methods during the course of this research.

3.3.4 Nuanced Differences Between Spatial and Garment Design Disciplines

Philpott (2011) critiques many design research studies, such as Cross (2001; 2006), for downplaying the nuanced differences between distinct design disciplines. There are important differences between spatial and garment design practices; for instance, differences between how garment designers use and manipulate textiles in comparison to a spatial designer designing and constructing a textile-based space or building.

For example, historically, due to fashion design's competitive and commercial nature, practitioners' knowledge (methods of design and dressmaking)—related to crafts and usually privileged by guilds—have been guarded as trade secrets; especially in haute couture (Finn, 2014). Finn (2014) emphasises that "practitioner knowledge of fashion design is […] explained through the description of associated technical skills such as drawing, pattern cutting and garment construction" (p.61).

Such hands-on skills are paramount in fashion design. Even when formal fashion design education occurs in technical colleges, such as London College of Fashion and Parsons New School in the US, it centres on hands-on approaches during apprenticeship training, teaching and assessment (Finn, 2014). This custom suggests recording fashion-technical knowledge in a written format, such as textbooks, is not the most effective way to transfer artisanal knowledge. Demonstration, combined with prolonged experiential and experimental practice, is required (Finn, 2014).

An example is when a garment designer drapes fabric on a mannequin. Draping and other mechanical fabric properties, such as tensile and shear, can be measured scientifically via numerical values and verbal description, which is important information in certain situations (in tensile fabric structure engineering for instance); but this type of knowledge is not necessarily what a garment designer requires to drape. He/she needs to experience how different fabrics drape and fold in different arrangements; for instance, regarding the fabric bias line. Therefore, undertaking formal studio courses with fashion design students was necessary to aggregate and integrate adequate knowledge into my research (see Subsection 3.3.5.1).

Many researchers emphasise the importance of working with material and making in the design process. However, some disciplines, such as architecture or interior design, are more abstract, and don't involve experiential explorations of materials as often, as the construction of a building is separate from the design process. However, they work with sketching, representations and model-making materials, which make for a different experience of design.

In the architectural and interior design process, in which specific materials and their defined characteristics are chosen carefully, late-in-the-design-process materials have become "solutions rather than potentials for innovation"; moreover, "the process of designing materials and designing products/buildings thereby become two separate processes, with limited influence on each other" (Heimdal and Rosenqvist, 2012, p.184).

As will be discussed in Subsection 3.3.5, the identified differences above were reflected in various research methods implemented in this research. As a spatial designer (in origin) it was therefore necessary for me to develop an adequate level of knowledge in the other involved discipline (garment design).

3.3.5 Methods/Tactics Discussion

Many resources about research methods specify that methods fall into two categories: data collection methods and data analysis/evaluation methods (Creswell, 2013; Denzin and Lincoln, 2011; Crouch and Pearce, 2012; Gray and Malins, 2004; Marshall and Rossman, 2016; Niedderer, 2013; Trochim, 2008). The first category, depending on the research paradigm, contains methods such as experiments, interviews, observation and participant observation. Whilst the second category, again depending on the research paradigm, includes comparison, interpretation, analysing artefacts and material culture, textual analysis, content analysis, narrative analysis, discourse analysis and statistical analysis.

However, research ‘through’ practice in art, design and architecture (ADA), necessitates finding research methods/techniques that suit the subject area (Lucas, 2016, p.191), and this involves generating and collecting data simultaneously, creating artefacts and designs, at the same time as containing a “substantial element of reflection, analysis and theorising on one’s design activity and design outcomes” (Pedgley, 2007, p.464) within an academic research framework (Gray and Malins, 2004) where the researcher is a practitioner and a researcher (Nelson, 2013; Niedderer, 2013; Pedgley and Wormald, 2007). Practice methods acknowledge and utilise multiple modes of knowing, plus designers’ skills, competences and learning/thinking styles. They share similar principles of creating a new reality and correspond with abductive reasoning (Cross, 2006; Groat and Wang, 2013; Herbert, 1988; Lucas, 2016; Handa, 2017; Niedderer, 2013).

I conducted this research as a solo practitioner-researcher from a spatial design background. I needed to build adequate practical knowledge in the practice of garment design and textile-based architectural design; in particular, tensile fabric architecture.

My subjective disciplinary cultural position (a designer; specifically, an interior architect), which is inherently multidisciplinary, influences the way I acquire and develop new knowledge. Nussbaumer (2001), quoting Kolb, states that “different learning styles are found within professions that are multidisciplinary and require a variety of skills” (p.39). Similar to other designers, as a designer-researcher I have different learning styles; besides abstract thinking, I excel in thinking-by-doing (spatial, experiential and visual thinking).

As such, employing methods of practice was crucial to embrace designers’/practitioners’ ways of knowing and types of knowledge. As Cross (2001) highlights, design knowledge and its different forms reside in activities and design outcomes. He emphasises the importance of engagement and reflection on these different activities and outcomes to access and gain different forms of design knowledge.

> Some of design knowledge is knowledge inherent in the activity of designing, gained through engaging and reflecting on that activity. Some of it is knowledge inherent in the artefacts of the artificial world (example, in their forms and configurations—knowledge that is used in copying form, reusing or varying aspects of existing artefacts), gained through using and reflecting upon those artefacts. Some of it is knowledge inherent in the process of manufacturing artefacts, gained through making and reflecting upon the making of those artefacts. And some of each of these forms of knowledge also can be gained through instruction in them. (Cross, 2001, pp.54-55)

Cross stresses that “design knowledge is to be located not only on a verbal level, but also in designers, design processes, and design objects” (Mareis, 2012, p.63). Similarly, in this research, theoretical and contextual resources failed to convey practical knowledge associated with the practice of garment design and spatial design. There was a need to gain practical expertise and knowledge through immersing myself in making, learning and designing with materials and tools.

In this strategy, I utilised my previous expertise in spatial design and tried to learn and use garment design methods in exploratory and experiential activities/experiments, or what I shall call *interdisciplinary ''through' practice investigations* of processes, methods and materials (see Subsection 3.3.5.1 and Chapter 4). First, in a pilot stage, then in a design project (Edinburgh College of Art ECA exhibition stand), which corresponded with Repko's (2008) interdisciplinary framework (Figure 3-2).

3.3.5.1 Interdisciplinary 'Through' Practice Investigations

This method encompassed several sub-methods across garment and space design and fabrication techniques. For instance, architectural model making and drafting (physical and digital), joints and finishing details, and garment design pattern cutting and manipulation, gathering, darts, seams, boning, draping.

These interdisciplinary 'through' practice investigations/experiments occurred in two stages: a pilot stage and a design project. Practice held an experimental factor; particularly, during trial and error, attempting different options as part of this investigative process. Although 'experiment' has a specific scientific meaning, it is understood in this research in a broader sense as "something we engage in to discover consequences of actions that interest us" (Binder and Brandt, 2008, p.119). Inevitably, appraisal is a part of design processes. Similarly, the conventional process of interior/architectural design, to some extent, is not dissimilar to experimental methods for resolving a problem/hypothesis (Lucas, 2016).

When little is known about a situation, uncovering what works and what fails to investigate integration is a part of an experimental, reflective 'through' practice investigation. These investigations aimed to learn, understand and collect different insights and engage with different knowledge forms.

Pilot stage

Pilot studies have particular meaning and use in the social sciences. Since the 1940s, they have been helpful in disciplinary research in determining the suitability of many aspects of research, such as instruments, procedures and even sample population (Persaud, 2009).

In this research, I utilised a pilot study in its conventional sense to test some aspects of research, for instance, the suitability of digital tools. However, I also adopt the use of a pilot study to the context of interdisciplinary research process and research through practice. I used the term pilot *stage* to emphasise that it is also a part of a process, rather than merely an end in itself. Below, I discuss, in three points, how piloting was used/adopted in this research context and what was conducted at this stage.

Firstly, this pilot stage was utilised in a conventional sense to test the feasibility of virtual environment investigation and utilisation of computer-aided design (CAD) and computer-aided design manufacturing (CAM) tools. Digital design and fabrication tools were proposed in this research, as they are increasingly integral to current interior/architectural design. Simulation research using digital tools has been exploited in architectural research to test scenarios, such as fire evacuation or social interaction, before spaces are constructed (Groat and Wang, 2013). CAD-CAM is also increasingly becoming an integral to traditional, hands-on garment design practices.

Digital explorations at this stage encompassed 2D experiments in drawing garment patterns using standard architectural drafting software (AutoCAD), and activities/experiments involving fabric behaviour simulation and garment modelling using multi-purpose 3D modelling and visualisation software

(3dsMAX) and SketchUp modelling the hyperbolic paraboloid (a basic shape in tensile fabric structures).

Secondly, adaptation of pilot study was related to the interdisciplinary research process. This stage was mainly explorative, concerning how interdisciplinary integration can happen and its possible pathways. At this stage, much was unknown about the research topic, and about implementing research ‘through’ practice within an interdisciplinary research framework in its two stages, as “the literature on interdisciplinarity has less to say about the integration of disciplinary experiential knowledge” (Barnes and Melles, 2007, p.5). Repko (2008) provides a general model of how integration can happen; however, this model is not directed at research ‘through’ practice.

Therefore, this pilot stage was experimental. Referring again to Repko’s (2008) interdisciplinary research process (Figure 3-2), Stage A (drawing in disciplinary insights and building adequacy), this piloting stage aimed to gain practical knowledge (‘adequacy’) of relevant disciplinary elements (e.g. methods, techniques) in garment design or textile-based architecture through self-learning: reading garment design and construction materials, working and ‘being’ in the fashion design workshop and consulting fashion tutors, technicians and postgraduate students.

This piloting stage was also related to Stage B (integrating insights and producing interdisciplinary understanding). It was used to investigate and study how integration occurs in practice through ‘learning-by-doing’. This helped to clarify integration practicalities, requirements, nuances and suitable settings, and define its scope and potential pathways.

Thirdly, adaptation was also related to the context of practice research in a number of points:

- Rather than starting to experiment with a full-sized TSI space, the pilot study was conducted on a manageable scale. Unlike the conventional use of a pilot study, here, ‘scale’ expresses the physical scale of objects, rather than scale of sample size among a considered population. For example, I experimented with a garment pattern (sleeve) and a geometrical element (a sphere), rather than a full garment or a full-scale building, so that I could work on them at my desk in the studio.

- To experiment with potential garment design methods that could be integrated/’transferred’ to spatial design: methods such as manipulating a two-dimensional flat surface (fabric) into a three-dimensional form (garment)— were tested through architectural model making (maquette). Architectural methods of 2D drafting were also tested in plotting drawings for a garment part (sleeve). Given the difference in scale between garment and TSI spaces and the absence of the body (holding the garment), this research piloting stage also investigated textile-based architectural approaches: tensile fabric architecture, in particular, as it is the only approach that uses textiles as a skin *and* a structural element—unlike other approaches that employ textiles as a covering skin as identified in Chapter 2.
- To acquire an in-depth understanding of different fabric types’ behaviour, which are lightweight, fixable, flame redundant, stretch, strong. These are mainly suitable for indoors; however, the potential is available to use in outdoor materials as well.
- As I intended to experiment with a full space at later stages, it was necessary to find affordable material to use; therefore, I aimed to examine the convenience of calico fabric as a virgin material for experimentation.

This pilot stage involved several digital and physical hands-on experiments of object making/modelling and learning, a pattern cutting course and digital activities/experiments (see Chapter 4). These investigations, conducted in the fashion design workshop, enabled me to work alongside fashion design postgraduate students and tutors. Schatzki et al. (2001) and Lawson and Dorset (2009) highlight the social context in which experiential learning-by-doing happens. Lawson and Dorset (2009) consider expertise as a social and a cognitive construct that exists inside individuals and collectively in groups. Therefore, this research 'through' practice approach takes into consideration that experiential learning happens in a social context (see Chapter 4 for more details on the piloting process).

The focus of digital and hands-on activities/experiments was to answer the following questions:

- Could integration/transference be achieved and studied in a simulation study using digital tools?
- How are a garment and a textile-based space constructed in practice?
- How do various types of textile behaviour and properties impact design and construction methods and outcomes?
- What methods of garment design and construction can be integrated/transferred or applied to spatial design?
- How might this integration happen?
- Can this integration transform textile use in TSI space design and fabrication?
- If so, how might this be achieved?

Pilot study analysis

As will be demonstrated in Chapter 4, during the pilot stage I tried to build a level of knowledge in garment design in a number of hands-on experiments/activities where I was able to consult the pattern cutting tutor and couturier of the fashion department. However, analysing these experiments through reflection-on-action suggested that building 'adequacy' in garment making needs to be revisited. Therefore, I undertook training in pattern cutting and garment construction. Some of the hands-on experiments/activities and this training emerged as a mode of investigation through experiential learning in apprenticeship (learning from demonstration/ imitating).

This pilot stage was progress towards achieving integration (see Chapter 4). For instance, it enabled me to examine different methods used to construct garments, and to build an adequate level of practical knowledge. It also identified related insights (reflected in different methods, such as expertise from garment and space design) connected to the problem/phenomenon (the shared use of textiles to construct different artefacts). It narrowed the scope by excluding aspects that appeared irrelevant, such as surface texture[18] (see Chapter 4, Subsection 4.1.2, p.195). It indicated to focus further investigations on the creative process of manipulating a 2D flat surface (fabric) into a 3D form (garment) and testing methods, tools and notions which can be integrated/'transferred' to spatial design. Mainly, boning (ribbing), pattern blocking, draping and toile were suggested for further investigation.

This stage also confirmed the importance of hands-on and experiential investigations in contrast to the limitations that digital tools and the simulation study revealed. Combining hands-on and digital tools is proposed. However, using digital tools just as simulation and drafting tools will help to tackle the problem of big scale; in addition, physical experimenting on different scales was essential.

Investigations in this piloting stage aimed to achieve integration. The process of these investigations and the realised objects reflected some employment

[18] Texture and textile surface manipulation in garment design such as pleating, gathering, capitone (smocking), and the use of origami principles especially in Japanese designs, as well as 2D laser cutting and 3D CNC knitting which I defined in Appendix 4, Section 1.25, p.9, and p.10.

of garment design methods and techniques, but no fundamental change in fabric use (I still used padding to make the sphere stand up) (see Chapter 4).

This stage suggested situating future investigations and experiments of materials and processes in context, for instance, design and fabrication of a defined TSI space. Undertaking further investigations in context helps to give the study more focus and natural settings, such as, dealing with scale (a fundamental concept and tool in spatial design) and responding to a design brief (see next section and Chapter4).

Design project stage

At this stage, a design project (which involved experimentation through experiential design activity and outcomes) was adapted to frame my research aims 'through' practice investigations. This was a suitable choice of research method, as it created a defined environment to stimulate potential integration and to study its process in more depth. Moreover, many inherent qualities of the design project process—its inherently iterative process, the presence of reflection in and on action, and dealing with a concrete situation—supported the nature and the aim of this research's investigations. In addition to 'experiential learning'/thinking-by-doing, the way practitioners/designers think or acquire knowledge and develop skills is associated with the concept of 'situated learning'.[19] Lawson and Dorset (2009, p.280) explain that situated learning "holds that learning takes place best not in the formal classroom but in the very context in which it is to be applied". They note that this goes

[19] Jean Lave and Etienne Wenger are the first presenters of situated learning concept which highlight that "Humans are socially curious beings and learn mostly through social interaction with others. Learning does not take place in an individuals' mind, it is situated in a context in which participation of individuals to the communities of practice plays a vital role on situated learning process. Situated learning occurs generally when an individual is not intended or planned to learn. Participation and doing take main place in situated learning. Situated learning take place when learning is specific to the situation in which it is learned." (Ataizi, 2012, p 3082)

beyond the traditional view of design education as learning-by-doing, where the *context* of the situation of the doing is as important as the doing itself.

Similarly, investigation through a design project provided a context to investigate integration. However, noting this design activity did not focus on the finished artefact (an exhibition stand); rather, its aim was to guide and to create a setting with the potential to stimulate and trigger integration between the practices of garment and spatial design. The brief used in this design project was the same brief used in the augmenting case study by other designers (design students) (see Section 3.4 and Chapter 4).

3.3.5.2 Documentation

Based on analysing past research projects incorporating practice in art and design, Gray and Malins (2004, p.108, pp.113–114) specify different documentation research methods, such as photography, reflective research/journal/diary/logbook. This research process (pilot stage and design project) was accompanied by the reflective documentation/field notes of both process and outcomes: photographs and clusters of them as a visual memo; CGI and 2D-plotted drawings to document digital experiments/activities; a hand-written logbook converted into a digital reflective journal; a visual diary; reflective and critical writing (conference papers).

When I was deeply engaged in design, notetaking to describe an action or an object felt disturbing and inefficient. The tension between process and documentation has been expressed by scholars of practice-led research; for instance, Philpott (2011) states,

> In my experience, the task of documentation threatened to suffocate the creative process. The challenge faced by me ‘the researcher’ (as opposed to me ‘the designer’) to make my embodied, playful and intuitive practices explicit resulted in the loss of the organic spontaneity of my design methods. (p.42)

During initial practice investigations, I used a hand-written daily logbook, which I converted into a digital journal and inserted photographs with close-distance reflections. However, as modifications are easily made to digital records, I made several numbered copies. This was helpful in the final analytical stages, as examining different copies shows that some entries were omitted from later copies. For instance, in one section (see Appendix 4, Section 4.4, p.103) I mention that a postgraduate fashion student recommended some key materials on pattern cutting for traditional costumes showing the importance of social context, or being inside the 'community of practice' (Lave and Wenger, 1991). This also demonstrates that while creating the journal, at a close distance from practice, the importance of certain entries was not recognised.

However, at the start, proximity to events, while I had an incomplete picture of integration, made me underestimate the value of reflective documentation. This initial underestimation, together with my visual cognitive/learning style and a strength in visual/practical activities and materials over textual ones, made me reduce daily textual documentation in subsequent stages, especially for the design project.

At the design stage, writing notes/reflections became occasional; yet, I kept monthly digital presentations (shared with my supervisors) as a visual diary comprised of photographs with reflective statements about my progress/research materials/readings. I arranged notes in critical writing pieces, such as conference papers, and the writing for this thesis. Documentation was helpful, to trace thoughts, to reflect and to determine subsequent research steps (see Chapters 4 and 5).

3.4 Augmented 'Case Study' Strategy in an Art and Design Context

This section outlines my approach to the inclusion of a case study in my research. It discusses the decision to work with students, data collection techniques, case study and participation characteristics and justifications, and ethics.

The adaptation of social science approaches is not an uncommon strategy in art and design research. Gray and Malins (2004) explain that “research methods in art and design have been augmented with useful social science methods, usually adapted and/or re-contextualised in some way” (p.117). Similarly, I adopted strategies, methods and techniques used in social sciences to augment my ‘through’ practice research strategy; specifically, a case study. The inclusion of a case study is, in Patton’s (1990, 2002) terms, an “emergent sampling. In this strategy, permitting the sample to emerge during fieldwork is a response to the opportunities that arise in the field” (cited in Emmel, 2013, p.33). My case study was comprised of collaborative experiential design and creating an exhibition stand (ILW workshop and associated design project as a type of TSI space) in Edinburgh College of Art (ECA), within the college’s interior and fashion design departments.

Often the core aim of case studies is to understand a single situation/phenomenon in depth (Trochim and Donnelly, 2008), and this type of case study is defined as an ‘intrinsic’ case study. However, this was not my intention. Another type, called an ‘instrumental’ case study, is used “to help understand something outside the case by providing additional insight or helping illustrate a phenomenon or issue” (Creswell, 2008; Stak, 2008 cited in Crouch and Pearce, 2012, p.125). Likewise, I used a case study strategy loosely as an ‘instrumental’ case study to achieve a further aim, as I wished to reflect on my own practice by comparing data generated and collected from my research ‘through’ practice approach with that of other designers’ practices.

3.4.1 Implications of Working With Students Rather Than Professionals

I collaborated and coordinated with interior design department tutors at ECA to run a workshop in Innovative Learning Week[20] (February 2012). This was linked to a semester project involving the design and fabrication of an exhibition stand in the second semester. This is a collaboration between interior design and fashion design departments, where third-year interior design students design and build a stand to exhibit fashion design students' work. However, the relationship between these two groups was not an interdisciplinary focus; rather, it was a designer-client relationship. My research aim in this project implied pursuing a different type of relationship: an interdisciplinary practice and learning relationship between the two groups. The intention was that interior design students used garment design methods to design and construct the stand, with garment design students available to advise/tutor them on how to use textiles and garment design methods (see Chapter 4 for more details on the project).

Since this research is concerned with the practice, materials and activities of design and fabrication, designers—students or professionals—were the ideal individuals/groups to participate as knowledgeable participants (Guest, Namey and Mitchell, 2013). As will be demonstrated in Chapter 4, the inclusion of a case study with a group of design students arose as 'emergent sampling' (Emmel, 2014, p.33). However, when such an opportunity emerges it is important to discuss whether working with students, rather than professionals, will have any significance/limitations on this research.

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[20] (now the Festival of Creative Learning) is a week in February where regular teaching on many courses are replaced by alternative learning activities, giving students access to extra opportunities to develop new skills and prepare for employment.
< http://www.innovativelearning.ed.ac.uk/about>

Many researchers in architecture and design discuss the differences between academia and professional practice; namely, the environment of an academic in contrast to a professional studio, and students' and practitioners' approaches to design.

Regarding the research context, Lowson and Dorst (2009) state that the studio mimics practice. Lowson and Dorst also add that academic study lacks links with clients, manufacturers and consultants; therefore, students rely more on personal experience than when real clients and users are involved (2009). Furthermore, Cuff (1991) explains that students (future architects) attain experience with design as an isolated activity conducted in a 'risk-free' environment. In this case study, differences between student-hood and the profession were minimised through in a project with constraints of a 'real' brief, clients (fashion design students and tutors), budget and fabrication, and timescale.

Another point involves approach. According to Lowson and Dorst (2009), most students may follow 'convention-based design', relying heavily on "conventions: customs and habits; the set ways of working within a field" (p.68). Although approach might impact design outcomes, employing unconventional building material (textiles) and unconventional processes, methods, foundations and expertise (garment design) was designed to evoke unconventional responses. Additionally, it is unlikely that convention-based approaches can be avoided when working with professionals (Lowsen and Dorst, 2009).

Despite differences, "striking similarities" (Binder et al., 2011, p.24) are found between student and professional practice in the creative process, 'conceptual aspects of design work' and material considerations of the design process. Lloyd Thomas (2006) emphasises that a separation of design process and materiality exists in architectural professional practice and education. In architectural education, Chandler states that the "formal aspects of design are usually developed first, with material considerations brought in at a later stage and left to 'technical' studies" (Lloyd Thomas, 2006, p.03). Given these similarities, differences in the creative conceptual aspects of design work are not anticipated to have a fundamental impact on the experiential design activity of the case study.

To create a professional group for the duration of the study would have been a barrier to conducting the research. Thus, it was a pragmatic decision to work with students, based on established collaborations and links between two design departments in one location. A further advantage of this choice was maintaining natural settings and authenticity: students employ creative design processes in their design projects. Conducting real-life project/workshops is becoming a common part of university curricula: Sheffield University's architecture department brings clients and users into the academic studio through 'live projects'; Eindhoven University, Netherlands, uses projects as a central feature of its industrial design course (Lowsen, 2009).

Another significance of working with students is the link between education and contribution to research. As Attiwill and Stone suggest, students "will perceive benefits of participation in a discipline, an area of study or field of research that neither directly results from, nor is the generator of, interior design practice" (Cys, 2013, p.64, also Earnshaw, 2016, p.15). While this research is not about designers' education, it is intended to assist educational processes.

3.4.2 Choice of Case Study as a Research Strategy

According to Yin (2003, p.13) "when questions of 'how' are being posed, case studies provide an empirical enquiry focusing on a contemporary phenomenon within its real-life context". Sarvimaki (2018) builds on Yin's ideas about the relation between utilising case study and research questions in a design research context where the main types of questions are "how to design in a particular context or for specific users, how to apply certain technologies or principles, why something works or doesn't" (p.5). Case study research provides crucial data analysis and collection methods for contemporary settings, since it provides answers to questions such as, "how do people experience a certain context, why it is perceived in a certain way, how could a design improve it, and so on" (Sarvimaki, 2018, p.5).

Understandings of case studies across different fields, and their adaptation in design research, support a case study approach for this part of the research. First, it suits the explorative nature of the research question, which is a 'how' question: where, as a researcher, I had "little or no control over behavioural events" (Yin, 2013, p.2). Second, it utilises settings (ILW workshop/project) to observe how integration may happen and unfold. Third, it makes the analysis and interpretation of how designers use and understand the potential of textiles in spatial design possible, as it makes interpreting understanding of certain social reality possible (Lincoln and Guba, 2011).

3.4.3 Case Study Strategy in the Social Sciences, Art, Design and Architecture

In the social sciences, Yin defines the case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p.18).

Sarvimaki (2018) remarks that non-architectural case studies hardly mention design and architecture, given the limited amount of research conducted by architects and designers, apart from historical research. However, she asserts that the new paradigm shift in evidence-based and practice-led research adds design disciplines into the case study discourse. That said, 'case study' is a frequently employed term in architecture and other design disciplines.

Literature on case study research in architecture suggests they frequently involve studying a historical precedent (Sarvimaki, 2018). As yet, the term in architecture, academia and practice varies to the extent where it might cause disagreement. Sarvimaki (2018) highlights that, in many design schools and practices, the term ‘case study’ has been misused or misunderstood. Crouch and Pearce (2012), in a design context, also share Sarvimaki’s view that the case study has been understood in diverse ways.

Reviewing sources from architecture and design shows scholars in architectural research cite and reference social science sources regarding case study research (Groat and Wang, 2013; Lucas, 2016). Some architecture scholars, such as Groat and Wang (2013), make Yin’s definition of case study more applicable to architectural research by omitting the word ‘contemporary’, which allows for the inclusion of historical phenomena besides contemporary settings as a potential foci for case studies.

In art and design research, Postiglione (2013) states that a case study may be descriptive, explanatory, or explorative and based on an in-depth investigation of a single individual, group, or event. Citing Stake (2008), from qualitative social science research, and Liamputtong (2009), from medical social science research, Crouch and Pearce (2012) propose that, along with time and place, case studies are bounded by events, processes or activities to form a unit. They explain that, in a design context, “the unity of research might be a particular object, a system, a design process or a workplace such as a studio” (p.122). They also highlight that case studies might be identified at the research’s outset, while in others, “the case only emerges during the research process as its defining features become evident through analysis of data” (p.124).

This case study emerged during the research process, and its significant characters became apparent during reflective and analytical stages as an empirical inquiry investigating ‘contemporary’ design and fabrication processes and outcomes of a TSI space. It was bounded by interdisciplinary-oriented design and making activities unfolding in a 'real-life context'. These activities in the ILW workshop and design project form a 'coherent entity', bounded by space (studios and workshop), over a specific time-scale (one-week workshop and a semester project).

3.4.4 Conducting the Case Study

The literature addressing case studies demonstrates that there's no single way to conduct one (Trochim and Donnelly, 2008). Frequently, a combination of qualitative and quantitate approaches are used (such as unstructured interviewing and direct observation). However, case studies generally share the characteristics of qualitative research approaches, such as being a holistic approach to understand complexity embedded in real-life context which relies on multiple sources of evidence (Groat and Wang, 2013).

To understand case study as a qualitative approach, it is important to mark the difference between it and other positivist approaches, such as experiments. Iacono et al. (2009) explain,

> …attention is paid to contextual conditions, regarded as highly relevant to the phenomenon being investigated, whereas an experiment typically deliberately separates the phenomenon from its context and focuses on a number of variables. (p.40)

The use of multiple sources and techniques is a key feature to gather data about a specific problem (Crouch and Pearce, 2012). Creswell (1998, p.40) recommends us to "gather extensive material from multiple sources of information to provide an in-depth picture of the case". Using different methods in case studies validates research outcomes, as multiple methods attempt to provide different/robust perspectives; for instance, participant observation, observation, archival research and interviews (Groat and Wang, 2013). Since little was known about how integration occurs and the potential outcome of integration, this study took an explorative, open-ended and process-oriented approach.

3.4.4.1 Case Study Data

In this research, data generated through others' practice were collected through participant observation and two follow-up interviews, and compared to those generated from the interdisciplinary' through' practice strategy. Participant observation, a technique used in ethnography and psychology, was adapted for this case study. For instance, I participated, observed and interacted with design students and tutors through the design and fabrication process, attended meetings, presentations and construction sessions. I interviewed both the design-lead and fabrication-lead students in follow-up interviews to collect reflections and elicit views on the process of working across spatial and garment design practices, and how this may have transformed their approach and use of textiles in design and fabrication.

Various data can be collected from a case study through techniques such as in-depth interviews, observations and opportunistic conversations with participants, in addition to studying personal journals, documents, photographs, archives, physical artefacts or numerical data (Gray and Malins, 2004; Liamputtong, 2009; Patton, 2002; Yin, 2008). I collected documents surrounding the design process and its physical outcomes: ILW workshop advert/brief; design project brief; students' publicly published documentation on the internet, etc.; sketches and text; field-notes; and model photographs. The various types of data (photographs, notes, physical models) generated through this case study provided a comparable source to similar data types generated gathered through self-practice. Comparing one's own practice to others' is common in art and design practice-led research (Gray and Malins, 2004, p.105). This approach supported analysis and reflections on my own practice and helped overcome over-subjectivity by facilitating a holistic understanding of different practices.

I produced a design-making activities report, which contained several narrative descriptions capturing different stages (e.g. the ILW workshop and associated project) (see Chapter 4), discussion-reflection, and analytical, interpretive and critical writing, setting the case study in context (see Chapter 5).

In summary, I employed a case study collecting multiple data sources, to study a contemporary phenomenon/intervention (transformation of practice through interdisciplinarity); in real-life context, containing complex dynamics- (interdisciplinary design and fabrication); bound to time and space (the one-week ILW workshop and semester design project, in design studios and workshops). These many defining features became more evident during the research process, rather than at the start.

3.4.4.2 Participant Observation

Design disciplines, in academia or in practice, form cohesive communities of practice. Therefore, to trace and understand other designers' practices to compare with one's own self-practice implies using certain techniques sensitive to these factors, such as participant observation.

Participant observation is "frequently used to refer to a situation in which the researcher plays a naturally occurring, established role" (Groat and Wang, 2013, p.226). This technique originated in ethnographic research, which stems from anthropology. Among other qualitative research, such as ethnography, Creswell (1998) informs us that participant observation was developed in the social sciences and outlines several research activities for this approach, such as observing, interviewing and exploring emergent themes from human behaviours (e.g. design and making practice). Further, Iacono et al. (2009) highlight that participant observation enables the capture of tacit knowledge.

I observed students’ design approach, process, methods, media and design outcomes. Photographs and field-notes of models and processes formed important data. The advantage of photographs was to document the process and to give myself another chance, later, to reflect on the meaning of action (Keegan, 2009). I avoided video recording to prevent disturbing my participants; besides, it was impractical to record videos because events happened over an extended timescale, at different locations and times.

Also, neither photography nor recording can capture what is going on in designers’ minds (Lawson, 2004). Instead, interviews elucidated students’ interdisciplinary design and fabrication experience. Additionally, I attended student presentations, meetings, fabrication sessions, design and model development. For instance, I observed students’ use of garment design tools (e.g. sewing machine, pins, scissors) and the methods and techniques adopted to manipulate fabric in the ILW workshop.

During participant observation, photographs of models, drawings and images were collected. Visual and textual materials (project documentation and presentation) were also produced by students and published online (‘Fabritecture’) (see Subsection 3.4.4.4 for ethical considerations). I observed model development and photographs of final design outcomes, to understand designers’ uses and understandings of textiles via the process, how they experimented, and how textiles appeared in their final design.

Participant observation limitations

Participant observation encounters challenges by taking a dual role, both watching and participating, rather than observing (Trochim and Donnelly, 2008). It was challenging to combine two roles, to participate and to take notes during the ILW workshop. Describing a process/model can require a long description; therefore, I used visual memos (see Subsection 3.3.5.2).

Another challenge is obtaining access and/or balancing a role within the organisational/social setting (Iacono et al., 2009). Regarding researcher identity and role, Groat and Wang (2013) explain that,

> …the researcher's identity might be known by few or many, or revealed in more or less detail. Moreover, the researcher may participate to a greater or lesser degree in his apparent role; or he may take the stance of either an insider or outsider. Thus, participant observation can encompass enormous variation in how the researcher chooses to observe and participate in the phenomena being studied. (p.226)

Tutors at the interior design department facilitated access and collaborations between interior and fashion design departments. I held multiple roles: in the ILW workshop I was a coordinator/advisor/tutor/participant observer, which enabled me to interact and observe their practice; in the project I was available for advice, located in the interior design studio to conduct the practice-led part of this research, which facilitated the opportunity for follow-up interviews at a later stage.

"A major criticism levelled at participant observation is the potential lack of objectivity"— especially the insider view (Iacono et al., 2009, p.42). I was able to occupy an insider/outsider position: at the ILW workshop, I was not their formal tutor (I had no power over the students or their assessments); instantaneously, I was not their peer (despite being located in the same studio). I maintained this position to overcome potential personal relationships from influencing interactions (Iacono et al., 2009) (see Subsection 3.4.4.4 on ethics).

3.4.4.3 Follow-Up Interviews

After finishing the project, I conducted follow-up interviews with two students who played key roles in design and fabrication, as they had the most comprehensive experience over the whole design project (the ILW workshop, different stages of project design, the fabrication and installation of the exhibition stand at Graduate Fashion Week, London, June 2012).

I aimed to collect first-hand insights from students' perspectives of using textiles as a building material and garment design methods and processes; and how going through this process might have transformed their practice and their use and understanding of textiles or design process.

Observing what designers do or what they say might be insufficient, so interviews explored what happened from the students' perspective alongside my observations. Lawson (2004) suggests that via external observation we miss significant data, since "unfortunately the really interesting thing that happens in the design process may be hidden in designers' heads rather than being audible or visible" (p.288). Similarly, he highlights that using a simple technique, such as asking designers to tell us what they do, through interviews or reading what they write about their process, is imperative.

Interview limitations

Monette et al. (2013) state that cultural and sub-cultural expectations for 'appropriate behaviour' in an interview are part of a social relationship between the two parties. For instance, social dimensions such as age and minority status. They explain that, "generally the less social distance between people, the more freely, openly and honestly they will talk" (Monette, 2013, p.181). In the early stages of participant observation (the ILW workshop), I had an insider/outsider position. By the interview stage, after spending time working on my models in the studio my position had changed to become that of an insider: sharing a background in interior design and architecture, previous interactions, doing inter-related research and being located in the same studio, all facilitated open responses from the students.

Monette et al. (2013) demonstrate, "in all interpersonal contacts, including an interview relationship, people typically prefer to please rather than offend or alienate” (Monette, 2013, p.181). In reviewing a transcription of the interview with the design-lead student, I noticed that I ought to share my experience and views going through the same project. Initially, I was concerned that the interviewees had been influenced by my views on the experience, or if they wanted to be friendly. However, reviewing interview recordings shows that it was ‘coincidental’, rather than ‘influential’, that we shared many insights and experiences. For instance, the student replied with enthusiasm, sometimes interrupting with examples.

3.4.4.4 Ethics

The ILW workshop and project involved in this research were designed with students’ morale and benefits in mind. Concerns over ethical issues were minimised through the following procedures:

- Transparency (Iacono, Brown and Holtham, 2009): the IL workshop advert explicitly stated to the students that this project was linked to a semester project, and a collaboration with me and this research project.
- Students did not work outside their normal curriculum: the project and ILW workshop were integrated into regular curriculum projects and activities as a part of their learning—their tutors and I were keen on maintaining this. For instance, my design proposal was presented to receive feedback from the clients (fashion design students), not for further development by the students. The students developed and build their own projects, while I continued investigation and experimentation through developing and fabricating my models and design.
- I had no authority over the students: I met students in workshop/studio settings. I was not involved in assessment. The students knew I was a PhD student and they were informed about this research topic. I gave presentations about this research and my role was to tutor and advise

when required. Therefore, there was no pressure on students from these perspectives.

- I did not impose specific design paths on students: students remained independent in their ideas. I answered questions and explained where required, without directing or imposing ideas. Being their project, I was keen to see what they would achieve under ordinary design project conditions.
- Natural social interactions: during that period, I was located in the interior design studio for a range of students from undergraduate to master's and research students, I was a member of the student community; discussions, interactions and friendships arose.
- Design images use: all images used for personal projects were sourced from Cargocollective (2012) ('Fabritecture' website), where they are publicly available. This procedure is to ensure students/participants are happy to share their images, in line with Coghlan and Brydon-Miller (2014).
- Anonymisation: according to Hancock and Algozzine (2006), anonymisation of participants identity is an ethical requirement; therefore, I did not use student names in written notes, reflections or in the thesis. All images have no explicit personal information (anonymised).
- Interview consent forms: in light of the ethical procedure highlighted in the literature (Hancock and Algozzine, 2006) ECA and the UoE, consent forms were collected from interviewee students and names were anonymised.
- Student satisfaction: participants valued their experience, were proud of their work and innovative approach, and were satisfied with their learning facilitated by this opportunity. This can be observed in the introduction about their project (as stated on the project website Cargocollective (2012)) and in the interviews. Furthermore, the students' creative exhibition space design won the Best Stand Design

2012 Award. This has had an impact on their career development and work experience (e.g. listing their prize-winning project on their CVs and portfolios).

- Benefits to both parties: students received the opportunity to experience unconventional construction material and ways of working; similarly, the processes and outcomes are a source of data.
- Health and safety: students were inducted to a sewing machine by a technician in the ILW workshop—other tools were normal interior design materials. A risk assessment was authorised by the health and safety officer. Students completed a separate risk assessment for their final design.

In conclusion, this chapter demonstrated how, in order to answer this research's questions, I used interdisciplinarity and its core operation integration—of currently separate disciplinary practices of spatial and garment design—as a strategy for transformation and innovation in textile use, and as a way of knowing and producing new knowledge. However, research 'through' practice was also a crucial mode of inquiry in this *design* research, as it allows engagement with tacit and practical/experiential knowledge in addition to the imagining and creating of new realities in which integration can be achieved and studied. Therefore, I composed an interdisciplinary 'through' research strategy to apply the interdisciplinary research process in the context of *practice* research.

The dominant research strategy was an interdisciplinary 'through' practice strategy implementing concepts of reflective practice, experiential learning and designers' ways of knowing into Repko's (2008) interdisciplinary research framework. In a pilot stage, and then in a design project, this strategy encompassed reflexive design, making and learning activities using virtual and physical materials and models.

To assist reflection on the integration that occurred in my own reflexive design practice, I intended to compare data generated and collected from my own practice with that collected from other designers' practices. Hence, a case study strategy of the same design project, designed by other designers (design students), augmented and reflected upon this research 'through' practice. This case was studied through participant observation and follow-up interviews.

Chapter 4 Fashioning Space: Towards Integrated Practice

This chapter demonstrates the empirical research process in the interdisciplinary ‘through’ practice strategy employed through two stages: the piloting stage and the design project stage. Data was generated and collected through different experiential making, designing and learning activities.

Additionally, based on the augmenting case study of a design project, undertaken by other designers (design students), various documentation strategies were used to record their process and outcomes, as data were collected via participant observation and two follow-up interviews. Table 4:1 lays out this research process in graphical form.

Research question	**Strategy and method**	**Data**
How may integrating spatial and garment design practices transform spatial designers' use and understanding of the potential of textiles and their inherent properties in space design and fabrication? How does interdisciplinary integration happen?	**Interdisciplinary 'through' practice strategy**	
	Interdisciplinary 'through' practice investigations **Pilot stage:** a reflexive process of making and learning: 12 making and self-learning activities of space and garment parts, then undertaking garment construction and pattern cutting during 10 weeks of training. **Design project:** a reflexive process of designing and creating a space: implementing methods from spatial design and garment design, e.g. physical model making on different scales, sketching, digital modelling and rendering, detailing, three-dimensional printing, boning, draping and pattern cutting. **Documentation:** photography, logbook converted to a digital reflective journal, notetaking, digital slide presentations, two conference papers, CGI rendering images.	Photographs, logbook and digital reflective journal, physical objects (garment patterns, stitches and seam samples), garment pieces, digital models and screenshots, digital slide presentations. Photographs, reflective notes, TSI space physical scaled models, 1:1 mock-up model, digital models and CGI 3D renderings, 2D printed patterns, two pieces of critical writing (conference papers) and 'expertise' communicated in textual format—albeit with limitations.
	Augmenting case study strategy	
	Participant observation: ILW workshop presentation and fabrication meetings in the design project. **Two follow-up interviews:** interviews with lead design and lead fabrication students. **Documentation:** photography of models and process, notetaking and digital presentations, students' project website.	Observational and reflective notes and photographs, transcription of two follow-up interviews; two pieces of critical writing (conference papers); scaled models, 1:1 mock-up model and final design, workshop and project documents (advert and brief), students' documentation (photos and website), presentation slides.

Table 4:1: Overview of research strategies, methods and contextual and empirically generated/gathered data.

4.1 Interdisciplinary 'Through' Practice Strategy

I employed an interdisciplinary ‘through’ practice strategy to achieve and to study the integration of garment and spatial design practices ‘through’ practice. These investigations encompassed several sub-methods from spatial and garment design practices, including architectural drawing, model making (physical and digital), joints and finishing details. Furthermore, I learnt and used methods from garment design, such as pattern cutting and manipulation, gathering, darts, seams, boning and draping. In this section, I specify the methods, tools and documentation methods I used in these investigations throughout the two stages: the piloting stage and the design stage. These investigations took place between April 2011-March 2013.

4.1.1 Methods, Tools and Documentation

Digital methods: Digital simulation of different fabrics types and three-dimensional (3D) object modelling of garment parts, rendering, Computer-Generated Imagery (CGI) of digital models, and two-dimensional (2D) drafting/drawing and plotting of garment patterns, and architectural orthographic drawings and 3D printing.

Context for use: These methods are the dominantly used methods in spatial design and, more recently, in garment design.

Hardware: Windows operating system on laptop.

Software: Mainly 3ds Max 2011, AutoCAD 2011.

Software choice and context for use: 3ds Max is a multipurpose universal design and visualisation solution, commonly used by designers in design, architecture, movies and gaming. It is useful for design and visualisation and simulating areas with modelling, texturing, lighting rendering and animation.

AutoCAD 2011 is a standard vector-based Computer-Aided Design CAD and drafting software, used for spatial design and engineering and, increasingly, for finding wider applications.

Digital activity documentation: These included a handwritten logbook converted to a digital reflective journal, screenshots, rendered CG images, and digital and printed 2D garment patterns.

Hands-on methods: I learnt pattern cutting and fabric manipulation techniques, e.g. pleating**,** fleering, gathering, dart manipulation and ease, and garment assembly techniques such as stitching, architectural drawing and model making.

Hands-on methods context for use: Pattern cutting and manipulation techniques, such as the use of boning, are essential garment-making methods. Architectural drawing and model making are essential tools and concepts in spatial design and fabrication.

Hands-on experiments—tools and materials: These included garment construction tools (pins, needles, scissors, pencils, an architectural geometry square ruler, chalk, a rotary cutter, cutting mat, measuring tape, working surfaces and industrial sewing machines at the fashion and costume workshop of Edinburgh College of Art [ECA]); fabrics (Calico, Tyvek, red Mache, felt, Lycra and recycled parachute Ripstop fabric); tracing and pattern cutting paper; boning materials (fibreglass rods, brass ferrules); ready-made patterns (Nakamichi, 2011; 2010; Ramos, 2011); Electrical Resistance Welded (ERW) tubing; aluminium poles and screws; loop hooks (used in earrings); jewellery wires; and a wire-wrapping tool.

Hands-on experiments—documentation: Photography (photographs of objects and process); objects (spheres, sleeves, tutorials folder containing methods and skills learnt and various seam types, garment parts and patterns and architectural models of different scales); handwritten logbook converted to a digital reflective journal; digital slide presentation; digital and printed 2D sleeve patterns; and space divider patterns (see Appendix 4).

4.1.2 Piloting Stage

Digital design and visualisation and my previous experience

Initially, it was proposed that this research be conducted primarily as a simulation study in a virtual environment, using 3ds Max 3D software, based on experiments with physical samples that could be fed into digital investigations. This strategy was investigated as part of my master's research: a simulation colour change study of a smart textile-based structure, fed by experimentation with actual physical samples, first on a fashion show stage, then on a concert stage (Fallouh, 2010) (Figures 4-1 and 4-2).

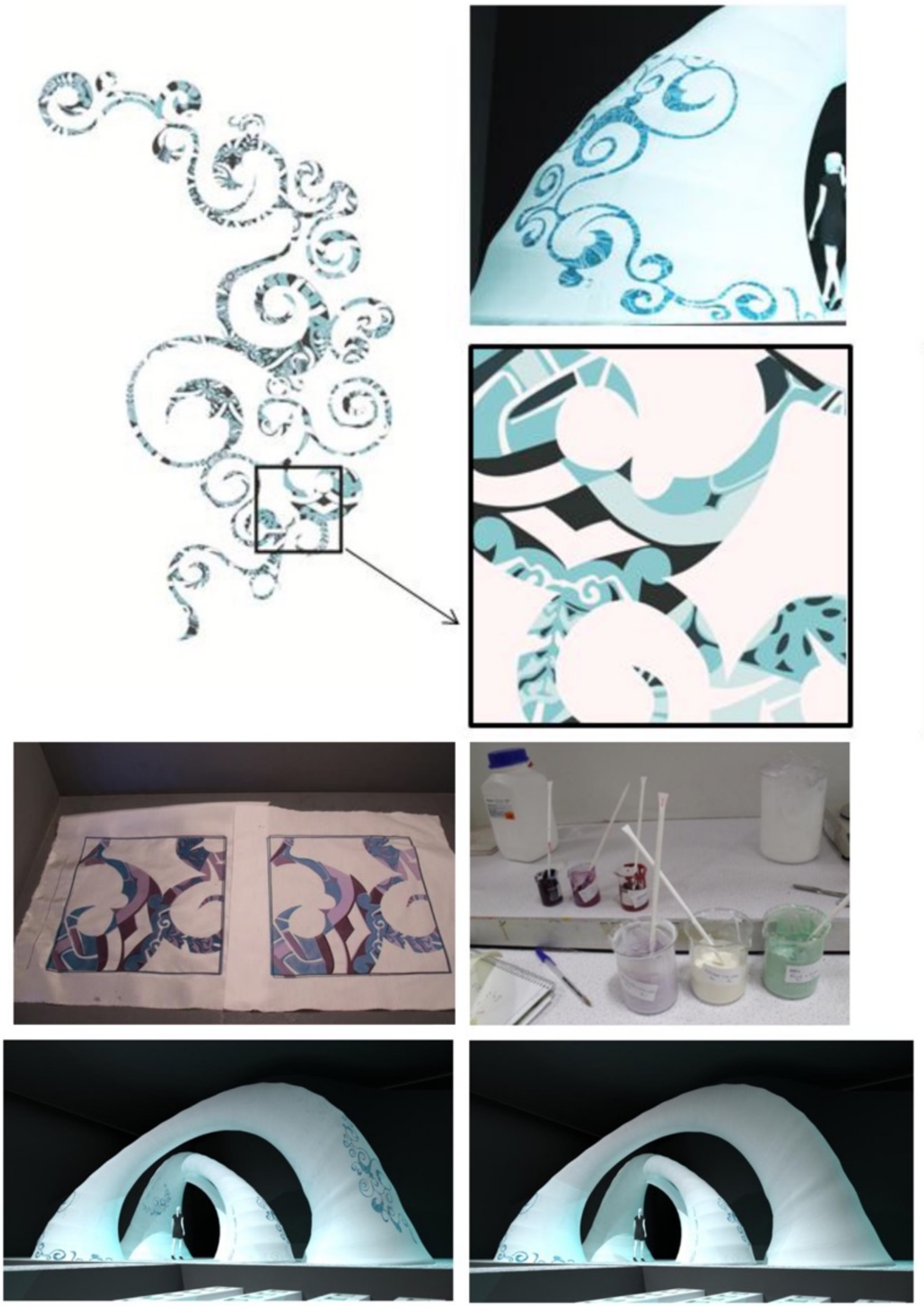

Figure 4-1: Simulation study for colour change. Top: printed pattern sample; middle: actual samples, thermochromic and glow-in-the-dark textiles; bottom: CGIs of textile-based concert stage, simulating colour change from coloured to colourless based on feed from actual samples. Image source: Author. 3D Software: 3ds Max.

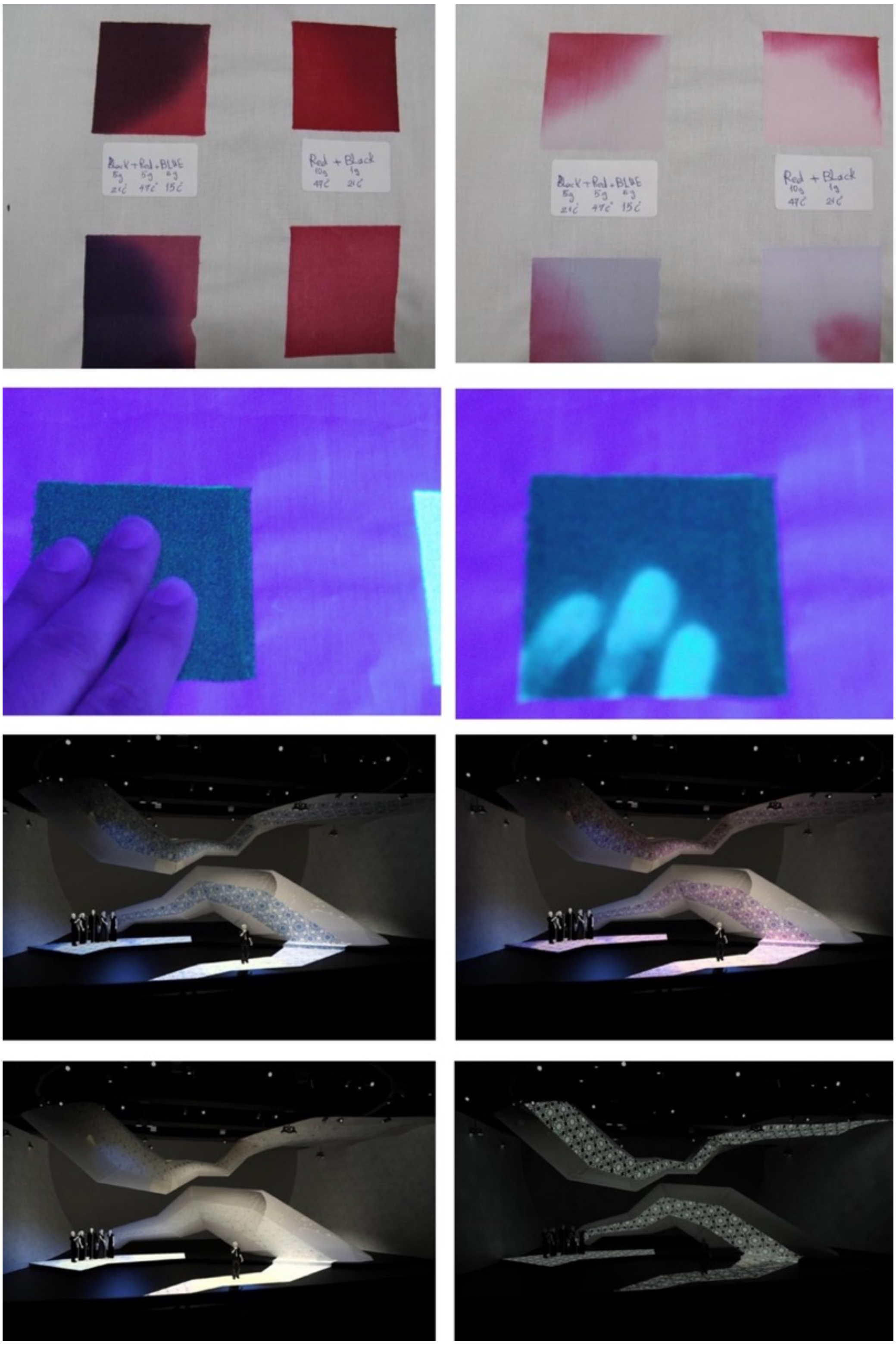

Figure 4-2: Simulation study for colour change. Top: actual samples, thermochromic and glow-in-the-dark textiles. Middle-bottom: CGIs of textile-based concert stage simulating colour change based on feed from actual samples. Image source: Author.

In my previous practice as an interior architect, I used this program to design, model and visualise spaces comprised, mainly, of rigid structures and materials, such as walls and flooring materials. Typical of the current use of textiles in interiors, the need for textile-based components was limited to soft furnishings, such as curtains and furniture upholstery, modelled using ‘mesh modelling’ in most cases (Figure 4-3). During my master's, I encountered issues with building and modelling textile-based structures. However, I did not investigate textile behaviour simulation, since colour change—rather than fabric behaviour—was the central issue. I used typical mesh and NURBS modelling systems, used for modelling solid materials, to model two textile-based designs (Figures 4-1 and 4-2).

Figure 4-3: Computer-aided design and visualisation of a domestic interior. Textile simulation is limited to soft furnishings. Image source: Author’s work. Software: 3ds Max and V-Ray rendering.

Digital experimentation started directly, given the available resources (hardware and software) and my 17 years of experience.[21] This

[21] In computer-aided design (CAD), visualisation and computer-aided manufacturing (CAM). My skills are advanced/expert level built through undergraduate and postgraduate education; professional practice in interior architectural design; and my teaching role as a tutor for CAD design and visualisation, and Digital Media for interior design programs at two universities in the UK. This expertise covers three-dimensional (3D) software (Autodesk 3ds Max and

experimentation targeted the simulation of textile manipulation, rather than colour change. Therefore, explorative object-making activities were conducted to determine the efficiency of digital tools to simulate fabrics' natural behaviour and perform operations, such as draping folding pattern manipulation, under different forces.

In this research, further investigations of 3ds Max tools and modifiers were required, since creating an interior space from textiles involves a different treatment from that of curtains and soft furnishings. Simulating textile-based structures digitally was not a straightforward process, and contrasts with simulating solid and orthogonal materials, such as wood and brick. I was encouraged to investigate this program further, since I had solid experience with it. For instance, it has a 'Cloth' system, which uses the two modifiers 'Cloth'[22] and 'Garment Maker'[23] for fabric simulation and garment making. This system was investigated through activities/experiments, as described below.

Activity 1: Digital 3D fabric behaviour simulating

I experimented with the Cloth modifier. Initially, I did not have expertise in garment construction and pattern making; therefore, experimenting with a rectangular, flag-shaped piece of cloth was a suitable way to become familiar with this system and test its tools in an introductory 'blowing flag' experiment (Autodesk, no date b). This allowed me to explore the Cloth modifier in conjunction with forces acting upon fabric, such as gravity and wind (Figure

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SketchUp); 2D drafting software (AutoCAD); graphic software (Adobe Photoshop, Illustrator and InDesign), and CAM techniques such as laser cutting and 3D printing.

[22] Cloth modifier: "The Cloth modifier is the heart of the Cloth system, and is applied to all objects in a scene that need to be part of the Cloth simulation. This is where one defines cloth and collision objects, assign properties and execute the simulation. Other controls include creating constraints, interactively dragging the cloth, and erasing parts of the simulation." Autodesk (no date a).

[23] Garment Maker modifier: "a modifier that is designed to put together 2D patterns that one can then use with cloth. With Garment Maker one can take a simple, flat, spline-based pattern and convert it to a mesh, arrange its panels, and create seams to sew the panels together. You can also specify internal seams line for creases and cuts." Autodesk (no date a).

4-4). Next, I wanted to experiment with how different fabric types are simulated in this software.

Figure 4-4: Flag experiment, simulation fabric behaviour under gravity and wind. Image source: Author.

Activity 2: Digital 3D simulating fabric types and properties

Selecting different fabric types (Burlap, Cashmere, Cotton, Flannel, Heavy Leather, Polyester, Rubber, Satin, Silk, Spandex and Stretched Cotton) enabled me to display their different properties and behaviours (Figure 4-5). The software simulated fabric properties and forces, such as bend, curve, stretch, compress, shear, density, damping, plasticity and thickness. I experimented with two distinct fabric types, Burlap and Silk, to test differences in 'bend' under gravity.

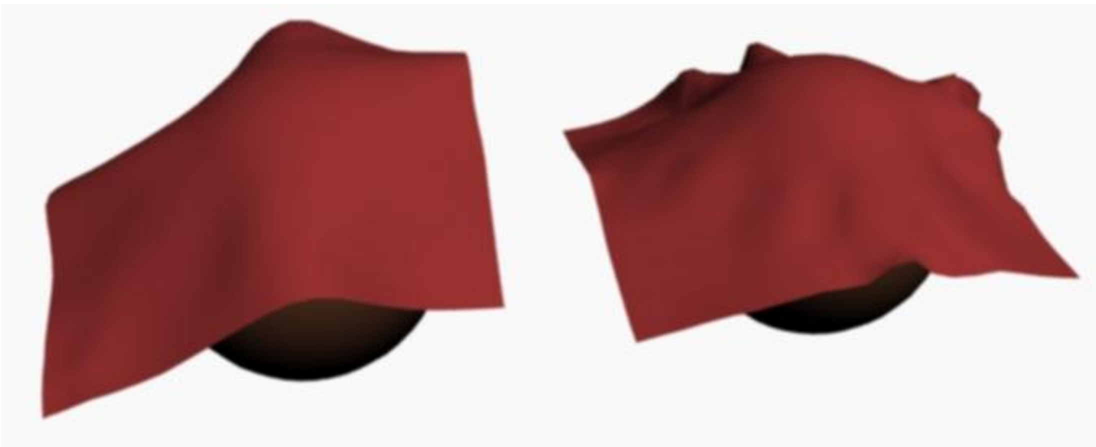
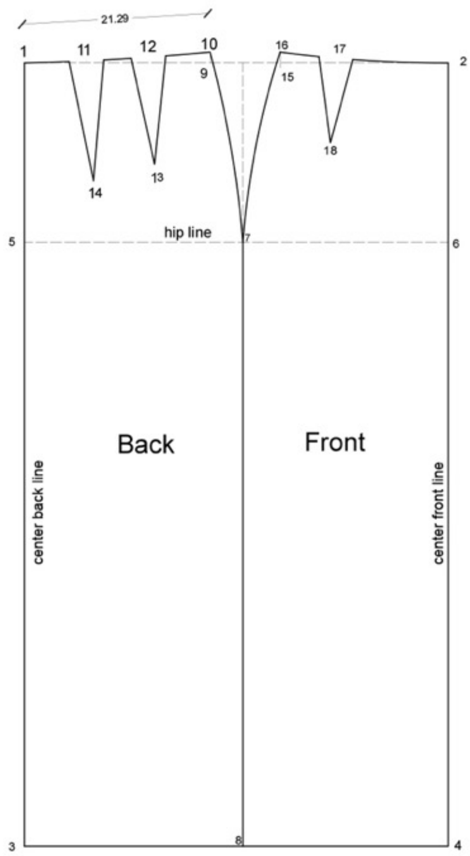
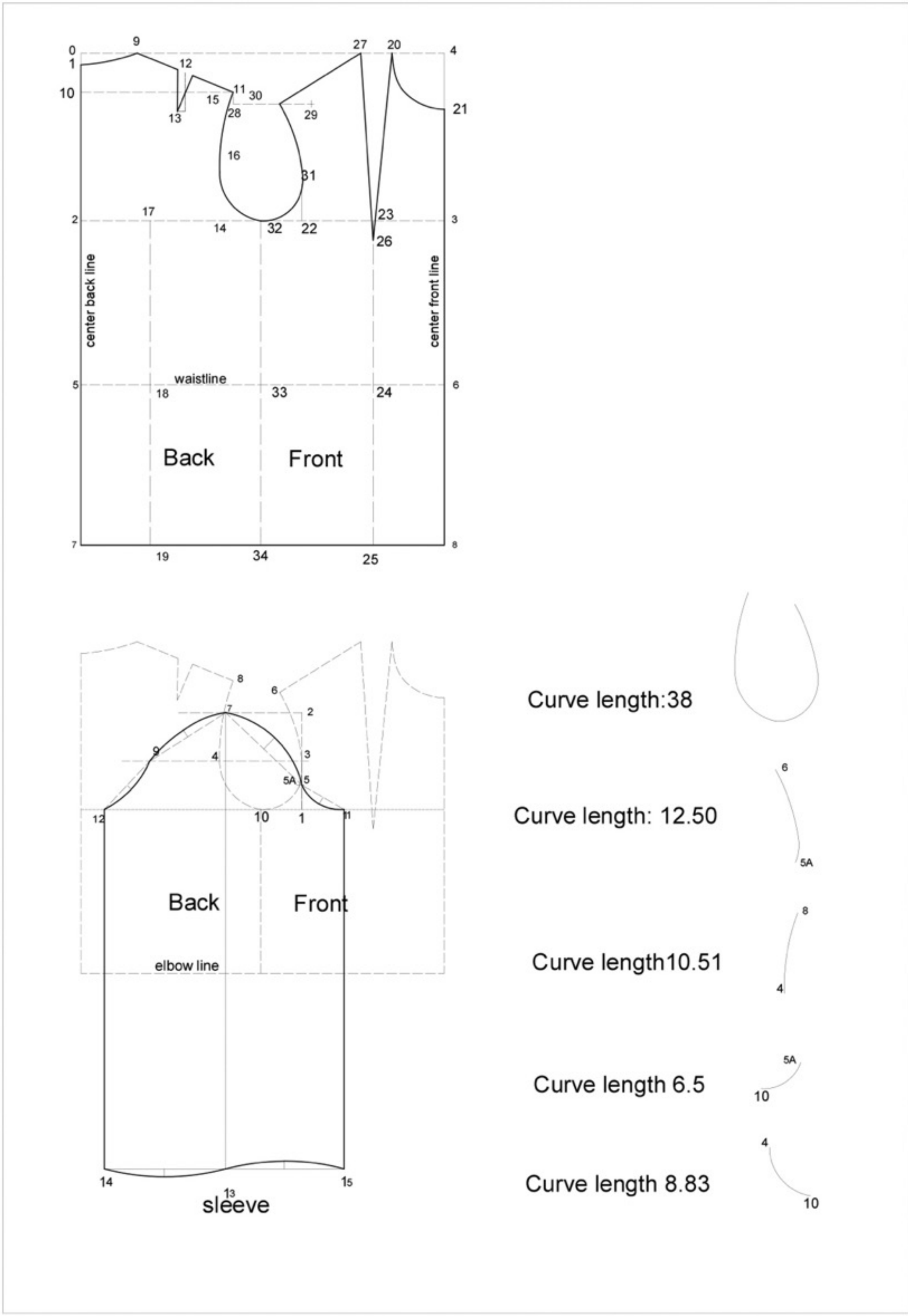


Figure 4-5: Simulation of differences in bend/draping simulation between burlap and silk material. Left: burlap; right: silk. Image source: Author.

To investigate the Cloth system's Garment Maker, digital 2D patterns were required, which were drawn using AutoCAD to test its suitability.

Activity 3: Digital 2D garment pattern drawing
I experimented with drawing ready-made basic bodice patterns of a top and skirt using AutoCAD. The process was smooth, as the software was efficient and easy to use. Drawings can be printed or cut using a laser cutter on any scale. The process was not significantly different from simple architectural drawings, except with regard to drawing and measuring the complex curve of a sleeve. The polyline draw option solves this by allowing the drawing of complex curves as a joint line (Figure 4-6).




center back line
center front line
waistline
Back
Front
Back
Front
elbow line
sleeve
Curve length:38
Curve length: 12.50
Curve length10.51
Curve length 6.5
Curve length 8.83

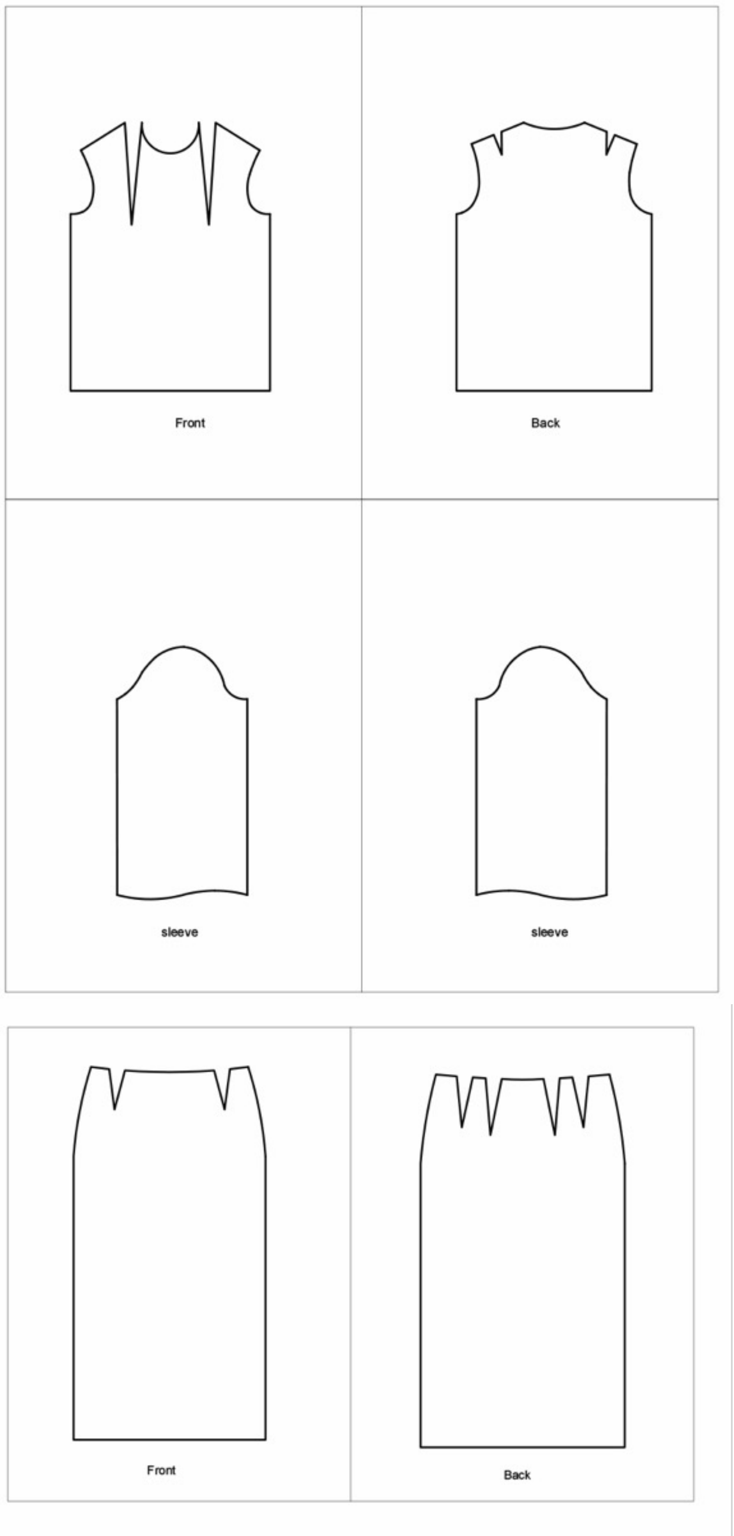


Figure 4-6: Bodice patterns of a skirt, top and sleeve pattern drawings using AutoCAD.

These digital patterns were imported to 3ds Max and used to simulate a garment.

Activity 4: Digital 3D garment-making modifiers

These patterns were converted into fabric and I experimented with draping and fitting them to the body model (Figure 4-7). This experiment showed that, in virtual simulations, three types of forces can be applied to fabric: gravity and wind (simulation natural forces), and local simulation (specific to 3D software and not a force in the real world). Applying local simulation allows garment panels to be simulated to fit a defined body (colliding object).

However, when using this colliding object modifier for a non-wearable purpose—to make space—no body exists inside the design; rather, we have a void. Several limitations arose when seeking to achieve certain forms. Therefore, to deal with these limitations, I created a supporting rigid object (which could be deleted later) and identified it according to the program as a body or 'colliding object'. However, this solution only dealt with specific problems in fitting fabric to the colliding object. Consequently, further explorations were required.

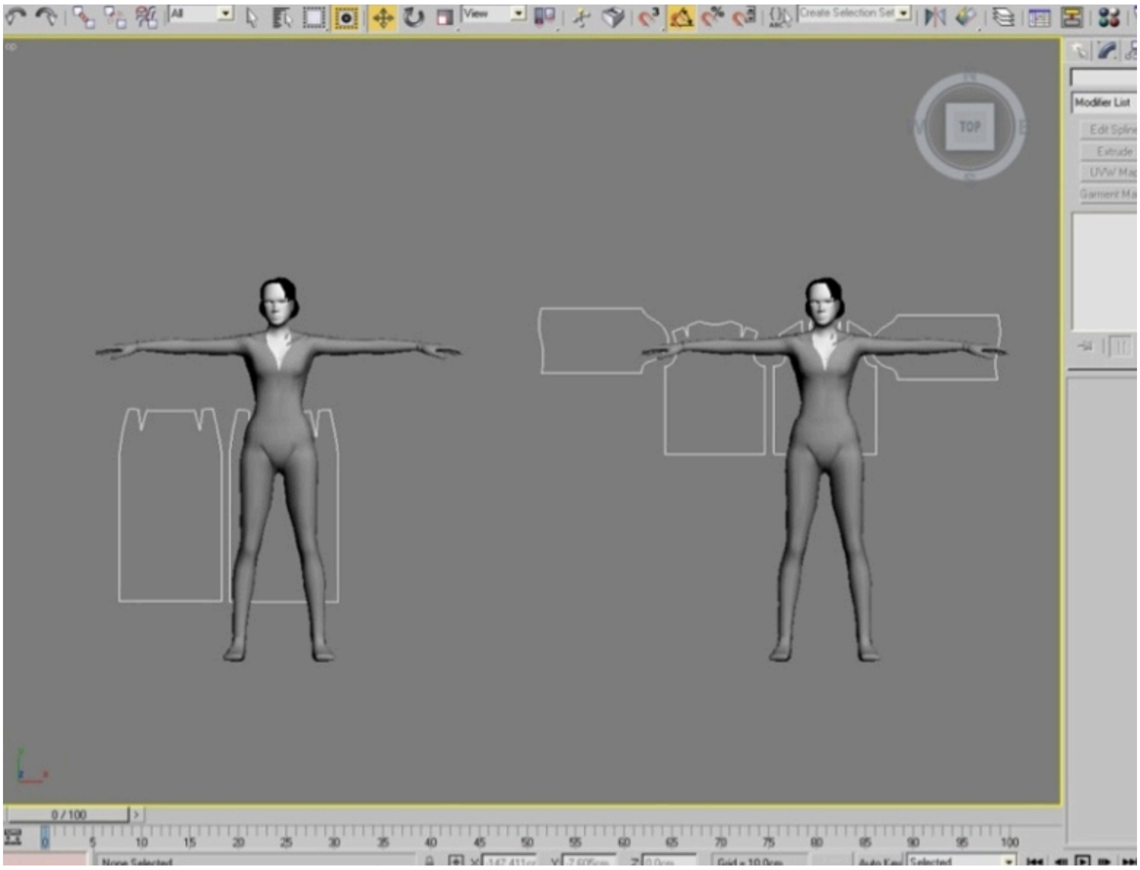


Figure 4-7: Screenshot, AutoCAD patterns imported to 3ds Max for garment simulation. Image source: Author.

I explored Marvellous Designer and CLO3D Virtual Fashion: software used in fashion design and simulation, which was suggested to me by a fashion design student. This software creates 3D clothing, and users can simulate quality garments compatible with many software products using pattern-based approaches to modelling (Figure 4-8). Importantly, the software enables the user to exploit the properties of different fabrics. From my observations, these programs possess spatial design potential; however, the software needs to be tested practically and requires a different research route from the current one. Integration using digital tools formulates a separate body of research, which is strongly recommended after the current research is accomplished.

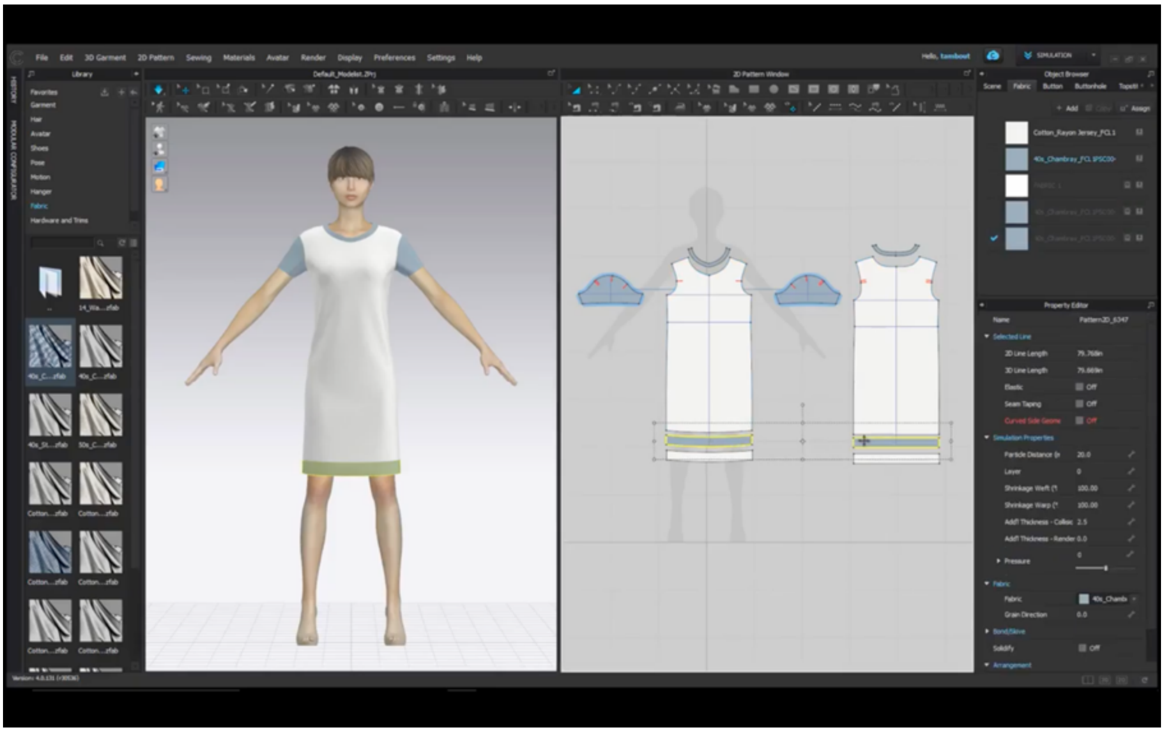


Figure 4-8: Using and editing fabric properties in CLO Virtual Fashion software. Image source: CLO (2018).

Reflection on digital investigation

Digital experimentation during this piloting process showed that these tools need development to be adapted to spatial settings. Limitations and gaps in these digital tools emphasised that experiments with physical materials are crucial, as they facilitate a deeper understanding of actual material performance. This awareness of the natural performance of materials mitigates the limitations of digital programs. A balanced combination of these two practice types is proposed as a current solution for this research, in the form of design media.

In the atelier: preparations and introduction to the fashion workshop

I conducted these experiments at the ECA fashion and costume workshop, which I attended most days of the week for five months. By working alongside undergraduates and master's students, fashion technicians and fashion design and pattern-cutting tutors, I aimed to operate in the same work environment in which garment designers work in practice, and to experiment with textile and garment design techniques. I did this as, “finding out who designers are and what they do determines how to find ways of researching” (Crouch and Pearce, 2012).

I was introduced to the workshop’s different facilities and routines, including a variety of fabrics in the fabric shop, boning materials, working surfaces, ironing facilities and industrial sewing machines. I underwent some basic tutorials in machine sewing using cardboard. I recycled a storage card box to create a portable space for experiments, which I painted black to create a mini-studio/stage-like space for photographing experiments (Figure 4-9). I also visited jewellery, wood/laser cutting and metal workshops at the ECA to look at the available materials and tools.

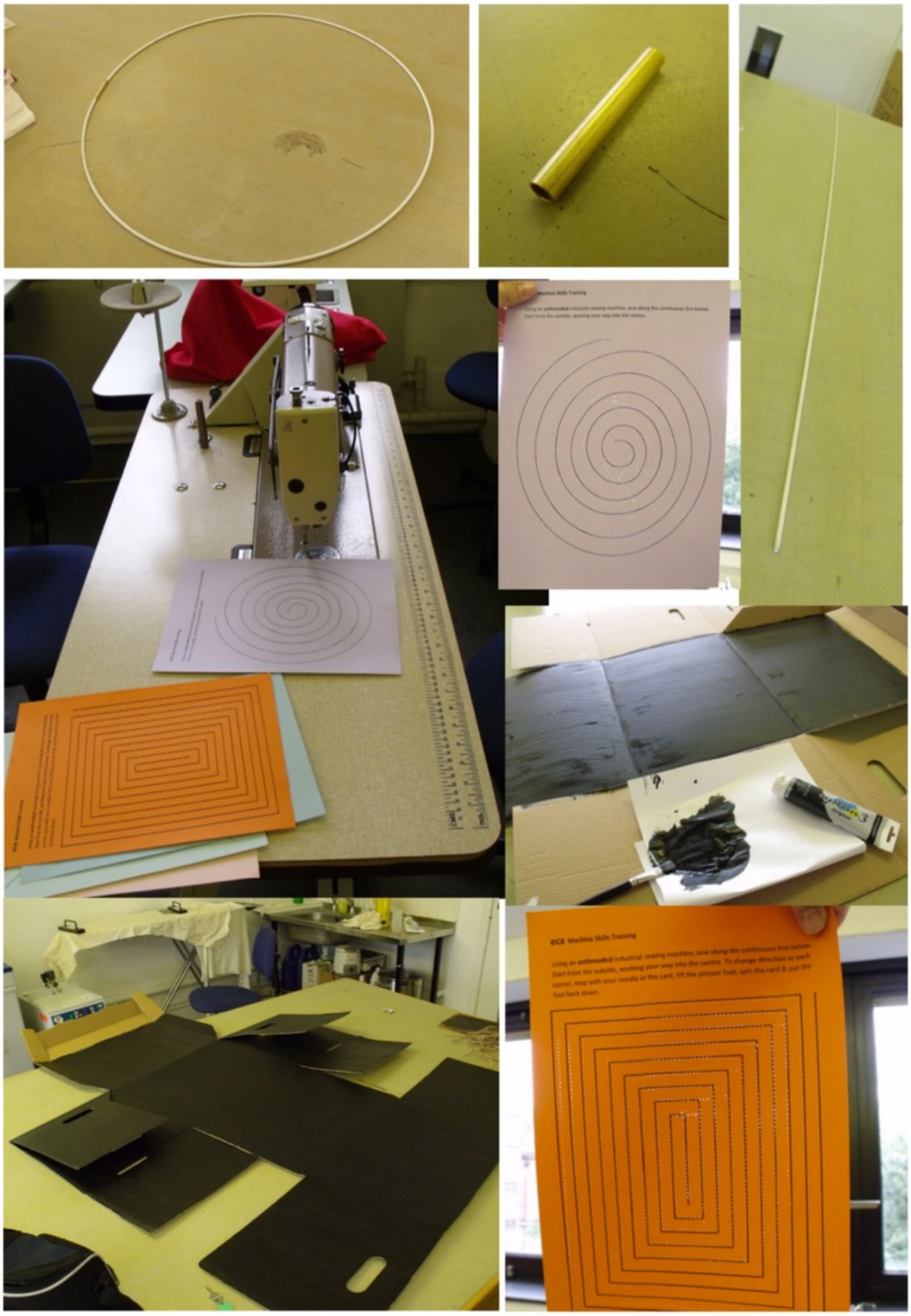


Figure 4-9: Hands-on activity preparations: industrial sewing machine skills tutorials; boning materials; recycling a card box to create a portable envelope in which to place objects, observe them and take photographs.

Activity 5: Hands-on sphere and sleeve making and digital pattern drawing

I experimented with inexpensive fabrics such as Calico, which is used to make toile for garment designs using woven fabrics. Different weights of Calico match different final garment fabrics, and stretch versions can be used for designs with jersey fabrics.

In this experiment, I created objects of a manageable size. For instance, I made one element from a garment (sleeve) and one element from spatial design (a sphere) using physical and digital tools (instead of creating a whole garment and a whole space). I aimed to form a sphere using a garment-making approach, and the sleeve using an architectural approach, to experiment with creating the two forms in different ways (Figure 4-10).

To make these two objects required patterns. I started by preparing and drawing patterns for the sleeve and the sphere. Having no previous pattern-cutting experience, I followed tutorials and copied ready-made patterns. Sleeve patterns were taken from pattern-cutting books (Nakamichi, 2007; 2010) and sphere patterns from online resources (Ramos, 2011). In the workshop, interaction with students occurred spontaneously. One master's student saw my work and recommended key pattern-cutting books by Janet Arnold (1984; 1985), who designed patterns for traditional English women's dresses. Arnold's *Patterns of Fashion 1*, *2*, *3* and *4* provided useful information about traditional construction of volume between 1560 and 1860; the books were inspiring for both pattern cutting and supporting structure, as they contained padding and ruff patterns and techniques.

Sleeve:

I used an innovative sleeve pattern tutorial (Nakamichi, 2007, pp.44-45) (Figure 4-10). This geometric and architectural sleeve form enabled me to draw patterns using AutoCAD, as the process of drawing these patterns depended on geometry. I printed the pattern to create a paper draft and reflected in my Reflexive Research Journal that, “This sleeve was interesting because its structures allow adjusting its form.”

Figure 4-10: Ball-shaped accordion sleeve tutorial (paper). Image source: Author.

Sphere:

Online sphere/ball patterns (Ramos, 2011) contained a variety of different designs, including square, triangle and hexagon. The variety of different patterns in which a sleeve and sphere could be achieved was remarkable (Appendix 4, Section 4.4, p.107). Three spheres were made with different pattern shapes (Figures 4-11 and 4-13).

Figure 4-11: Hexagonal ball patterns of the platonic sphere based on online tutorials.

Activity 6: Hands-on sphere pattern manipulation

At the workshop, I spoke with a pattern-cutting couture tutor from the ECA. I wanted to understand how an architectural geometric shape is handled from a garment-making perspective, using those particular skills and expertise. He suggested manipulation techniques, such as darts[24] and ease, and demonstrated them. It was remarkable to observe how simple techniques could direct textile, transform its hexagonal pattern and open new solutions.

After this demonstration, I experimented with panels/patterns, manipulating them using different sewing modifiers such as darts, ease, flaring and gathering (the latter three add volume to garments). Additionally, I distorted the edges of the hexagonal pattern (Figures 4-12, 4-13 and 4-14).

[24] Typically in garment design, “blocks have darts to create shape over the bust, shoulders, and hips and to reduce the waist” (Parish, 2013, p.36).

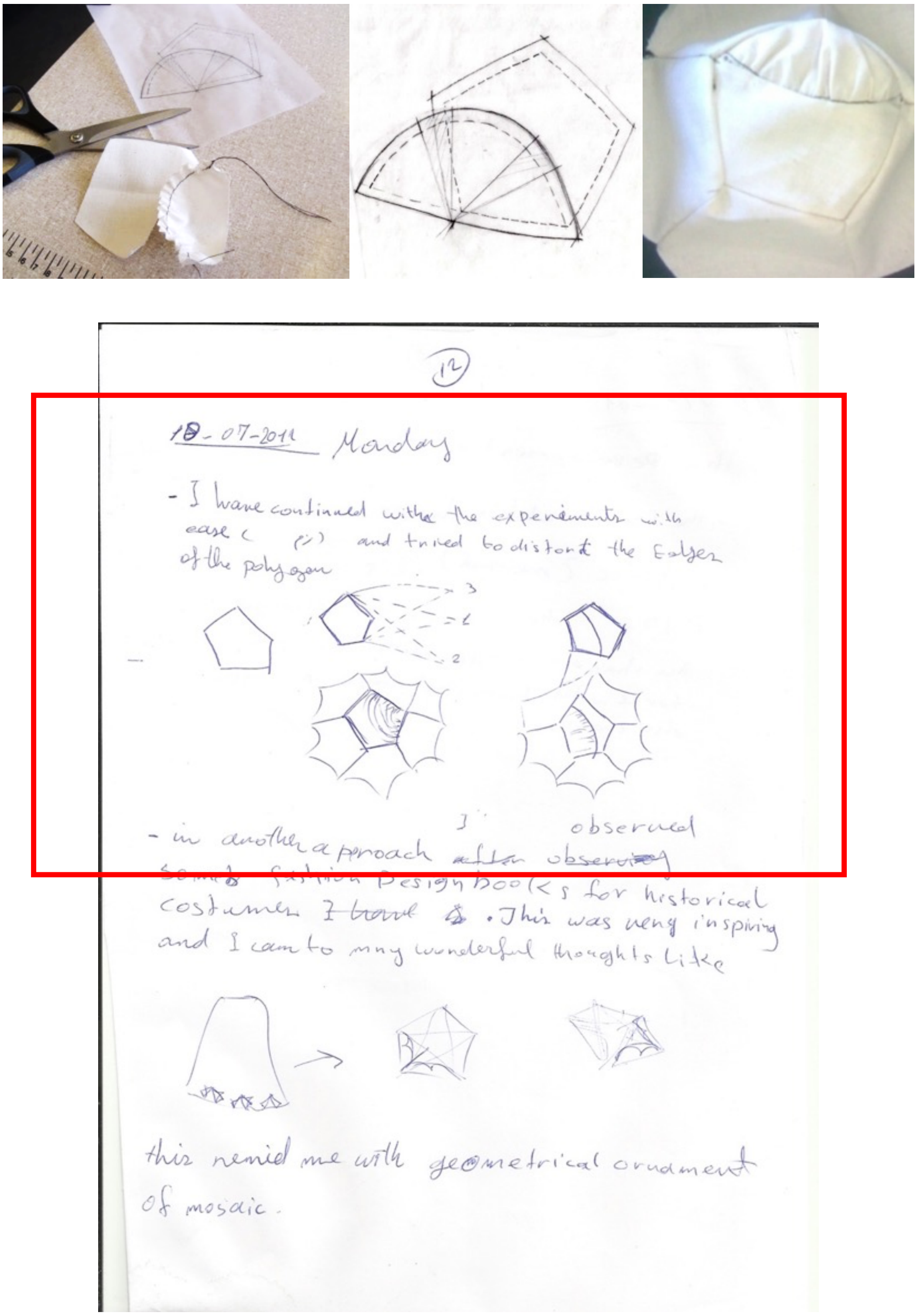


Figure 4-12: Pattern manipulation experiment with darts and ease/gathering use, logbook extract.

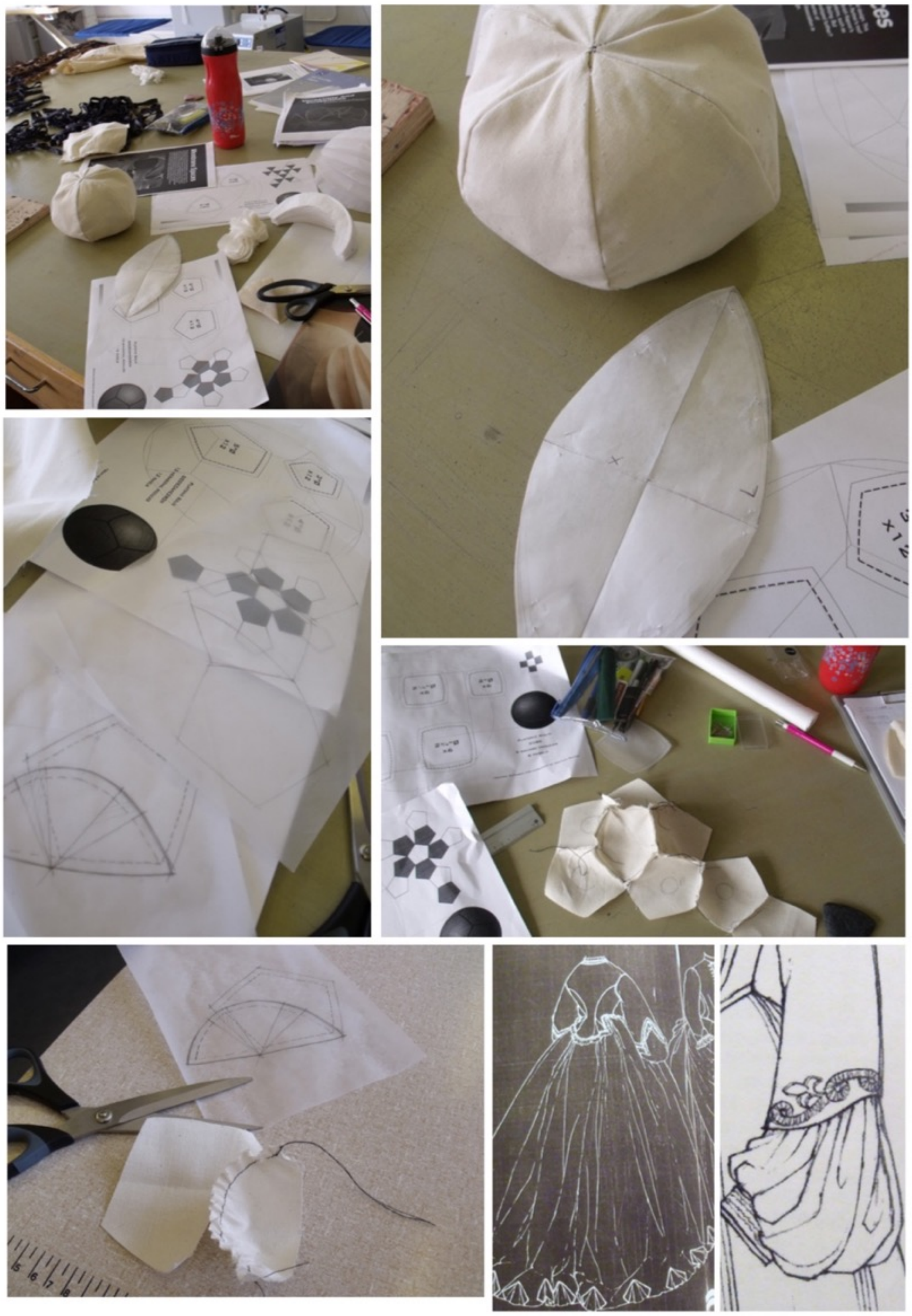


Figure 4-13: Pattern manipulation experimentation process.

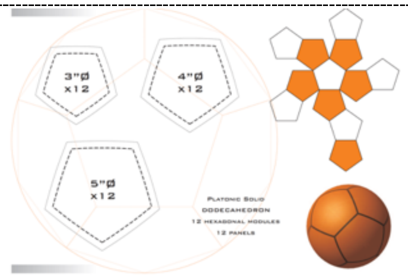
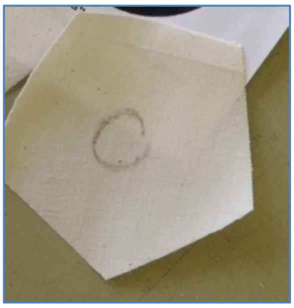
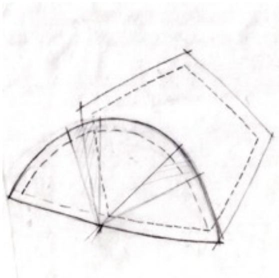
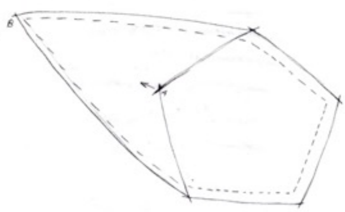
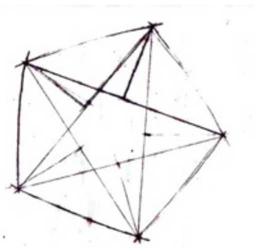
Pattern manipulation	Outcome
 Standard platonic sphere patterns joined	 Standard pattern
 Gathering combined with pattern manipulation	
 Gathering combined with pattern manipulation	
 Pattern manipulation in layers	

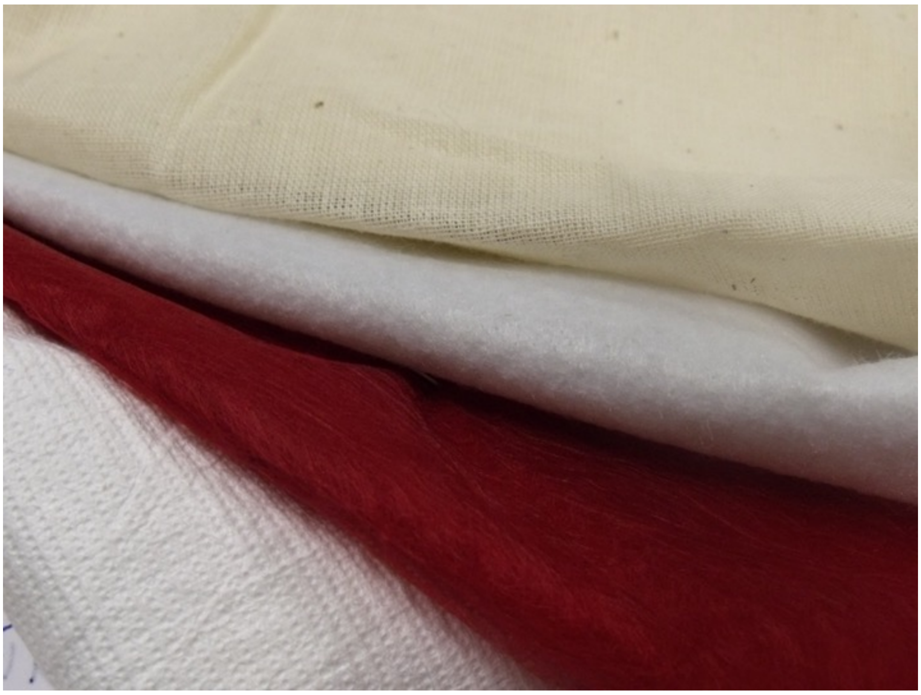
Figure 4-14: Pattern manipulation experiment using darts, ease and layers of fabric.

Activity 7: Hands-on exploration of different fabric types

Simultaneously, I investigated fabric types to find those most suitable for further investigation according to various criteria and properties: weight and economy were the most important of these.

Textile materiality plays an essential role in this research. Therefore, it was important to survey different textile types and manufacturers, and explore their different properties; for instance, opacity, transparency, weight, stretch, forgivingness and airtightness. Different textile types were explored and classified according to their properties. Three types—Calico, Tyvek and red Mache—were selected as part of multiple case studies (Figure 4-15). Calico because it is an economical material when experimenting with large quantities; Tyvek because it is lightweight, important for temporary spaces; and Lycra for its stretch qualities, which might result in a better finish. It was noted that when changing fabric type, the shape changed as a consequence. Colour, transparency and texture also made a difference.

Fabric felt like a malleable material. For instance, when trying to join patterns, it was possible to achieve neat results with small differences in panel size (even if not 100% accurate). This differs from solid-material assembly, to which I am accustomed due to my previous experience of scaled model making for interiors; solid materials cannot be joined unless the measurements are precise.



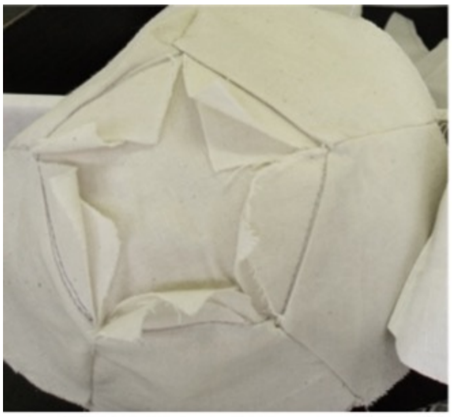


Figure 4-15: Experimentation with Calico, Tyvek and red Mache

Activity 8: Digital 2D pattern drawings of hyperbolic paraboloid tensile roof scale model

As a TSI space has an interior space scale, rather than a garment scale, I had to consider the architectural approaches of fabric architecture. And thus, 'How can tensile space be constructed in practice?'

Considering recent research in tensile structure, Hensel and Menges (2008) conducted a series of membrane research experiments on membrane arrays. These arrays reminded me of mosaic design, and so I cut fabric according to a pattern, not with basic holes. I used AutoCAD to draw 2D patterns (Figure 4-16) to make my first tensioned fabric shade. The fabric was cut using a simplified mosaic pattern that allowed regular holes and free edges to be held in tension. Investigations at this stage focused on building adequacy in tensile fabric architecture using physical and digital tools.

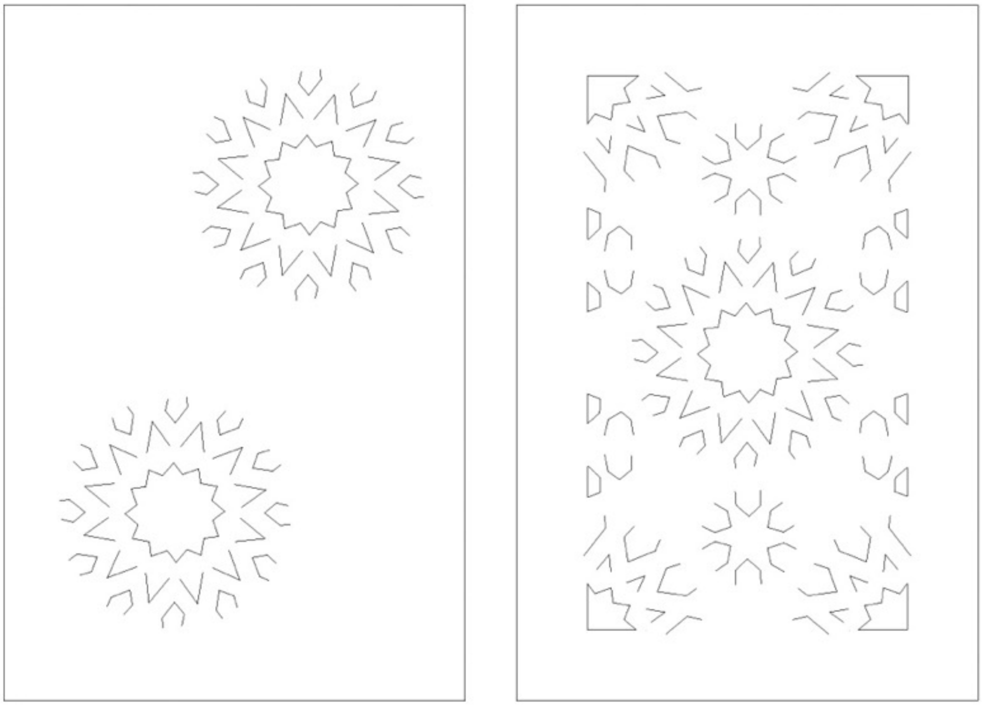


Figure 4-16: Explorations with a simplified mosaic pattern that allowed symmetric holes and corners to be held in tension; the pattern was laser cut from Lycra.

Activity 9: Hands-on hyperbolic paraboloid tensile roof scale model

I gained practical experience of the principles of tensile fabric structure by making a scale fabric model of the hyperbolic paraboloid[25] (see Chapter 2, Figure 2-5). I also explored the effect of surface manipulation by combining laser cutting with tensile fabric principles. I experimented with Lycra fabric, which was cut according to the simplified mosaic pattern described above (Figure 4-16). The shape changed gradually, from a basic double curvature surface to a more complex shape, as I held additional points and holes in tension (Figure 4-17).

[25] A surface curved in two opposite curvatures, 90° from each other, and fixed at four points, two low and two high. The simplest form of a tensile fabric structure.

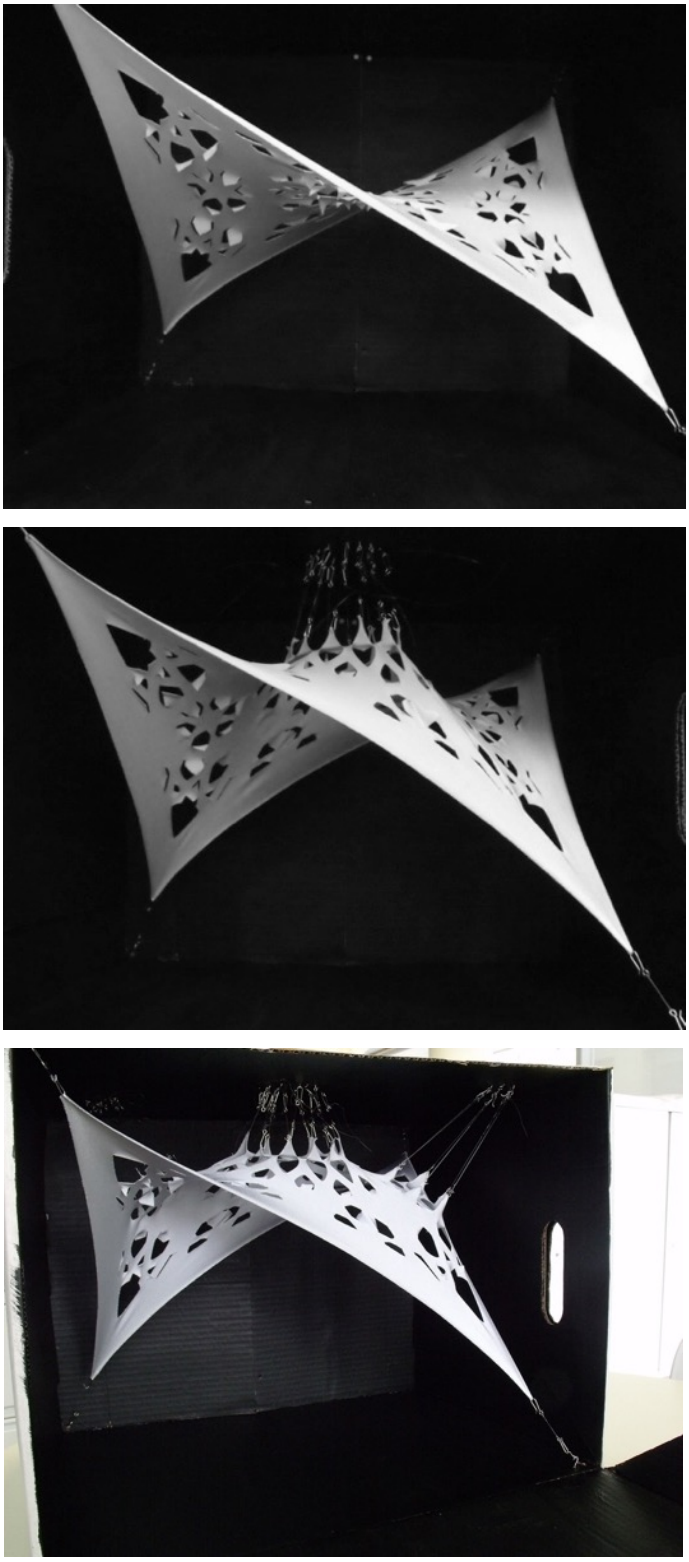


Figure 4-17: Top: fabric models of the Hyper anticlastic curvature. Middle: more complex form, as I held additional free points and holes in tension. Bottom: tensile surface with further manipulations. Image source: Author.

Activity 10: Hands-on boning use

In the workshop, I observed fashion and costume students' work and materials, and identified many of them. One key method was boning and ribbing. Boning materials support garment form; examples include ridgelines in corset making, fibreglass rods in crinoline making (Figure 4-18), and ferrules, which, like fibreglass (Figure 4-19), were originally used in kite making. Fibreglass rods come in 5 and 3.2mm width. Boning involves using these supporting elements to give fabric a certain shape without restricting flexibility completely. Rowan Mersh, a textile-based sculptor who explores form through the intuitive application of a material's inherent qualities, used boning in his fabric sculpture works. He used wearable sculpture-supporting elements and Lycra with the human body as the main load-bearing frame, and wooden cocktail sticks as the only reinforcement (Black, 2006) (Figure 4-20).

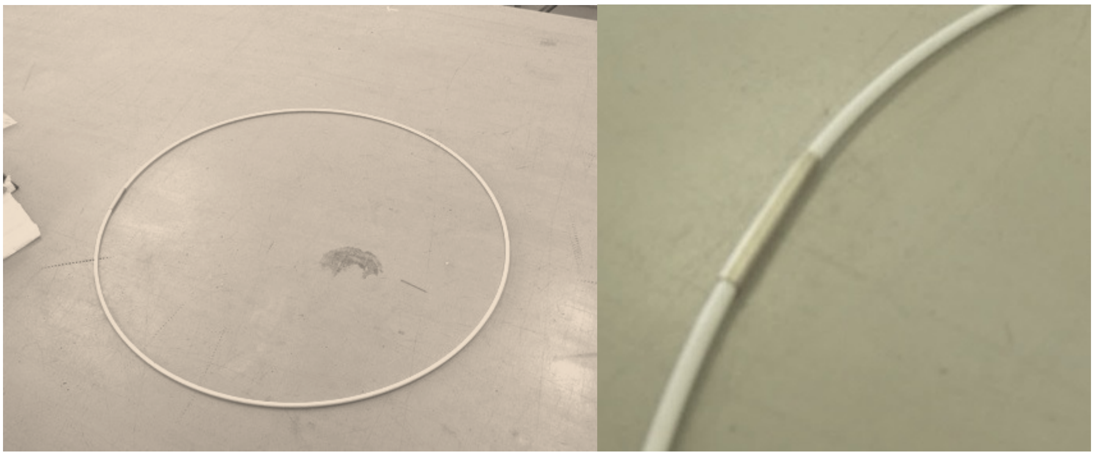


Figure 4-18: Fibreglass road curved and joined using a brass ferrule, used in a crinoline. Image source: Author.


Figure 4-19: Second-year costume design students at ECA. Left: use of padding. Right: an 18th-century pannier with boning (ribbing) to create volume.


Figure 4-20: Left: Rowan Mersh, fabric sculptor, 2005 (Black, 2006). Right: Arkadius Graduation Collection Show, London, 1999 (Weremczuk, 1999).

Observing the use of boning in garment design motivated my experimentation with boning in space design using stretch fabric with supporting elements. I created a white Lycra sleeve with wooden cocktail sticks as support. To employ this piece inside a space, I placed the piece in the black-painted cardboard box (Figures 4-21 and 4-22).

Figure 4-21: Experiments with white Lycra and wooden cocktail sticks in space. Image source: Author.

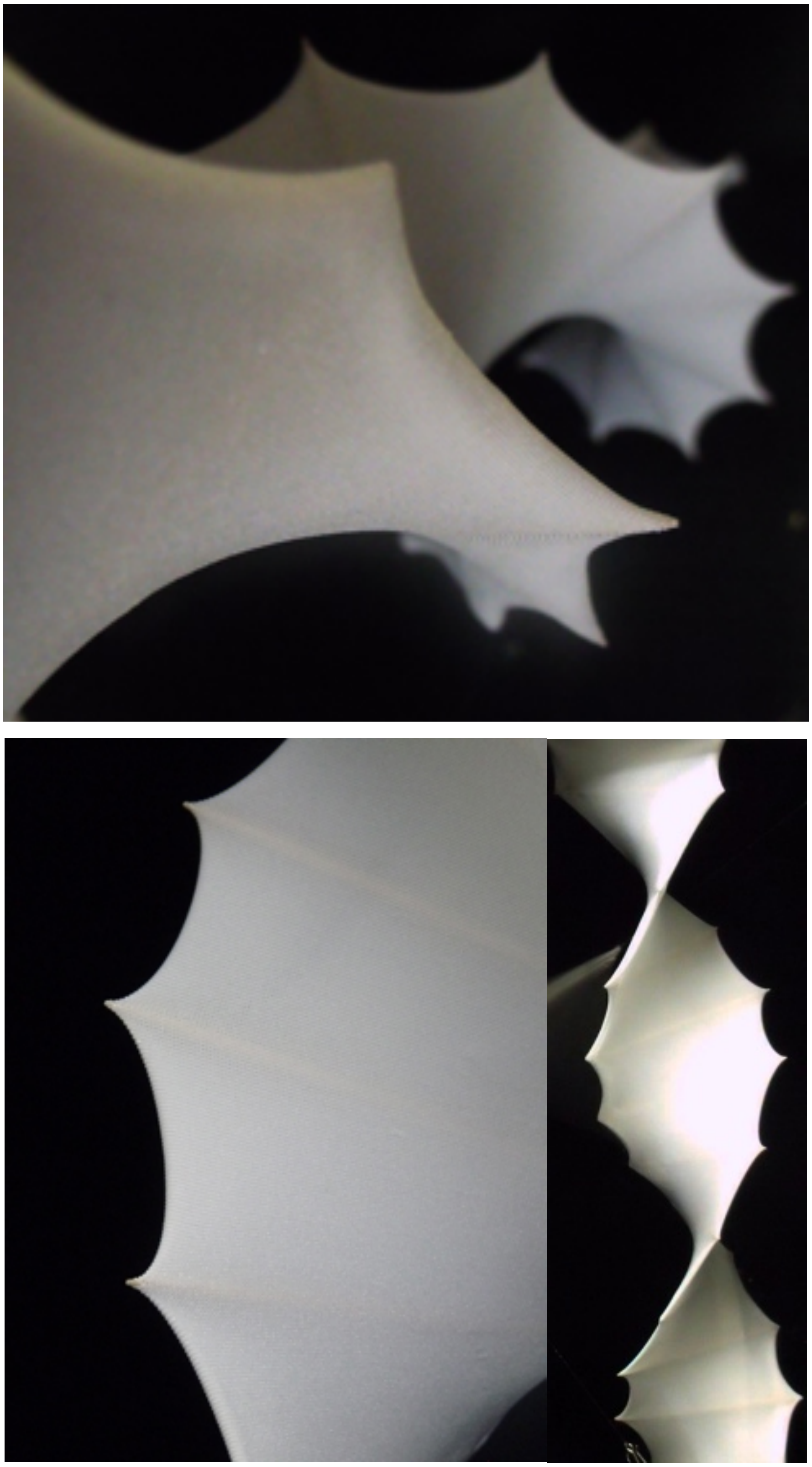


Figure 4-22: Experiments with white Lycra and wooden cocktail sticks.

On reflection, this technique reveals an important structural property of textiles as a fixable surface joining harder structural elements. In garment making, the human body is the main holder of the garment, in addition to the boning ridgeline of the corset and crinoline when used. Generally, in art installation, spatial design and architecture, wooden/steel frames, rods and cables support textiles in large-scale textile-based structures. Determining the holding structure/skeleton is a challenge when constructing a space using textiles.

Activity 11: Pattern-cutting and garment-construction training course
While I understood and analysed the basic patterns of the sphere, since it followed the mathematical rules of geometric shapes, I did not fully understand how sleeve patterns were created, what the rules and principles of design and construction were, and why. Hence, a further step was required to attain a more comprehensive understanding of how a garment was made. I decided to undergo an experiential learning activity by undertaking a training course in pattern cutting, to learn and practise a range of methods, tools and techniques for pattern cutting and garment construction and develop further understanding.

I underwent a training course in pattern cutting with second-year costume students, where I interacted and built relationships with students and their tutors and discussed their work, which facilitated access to greater knowledge than gained from reading. This corresponds with the idea that "mastery of practice cannot be gained from books or other inanimate sources. But can sometimes, though not always, be gained by prolonged social interaction with members of the culture that embeds the practice" (Schatzki et al., 2001, p.107).

This course used *Metric Pattern Cutting for Women's Wear* (Aldrich, 2008) as its main textbook, and included tutorials in basic pattern-cutting and sewing techniques, including different seam types, such as the piped cord seam and the lapped seam used in jeans (Figure 4-23). Plus the use of boning/ribbing materials, such as fibreglass to create and support garments' form, such as corsets and crinolines. I was also introduced to the bias cut, made in a 45° direction to a fabric's grainline to make it drape nicely. It is necessary to know about grainline when cutting fabric patterns in different directions. Cutting in a 45° direction makes woven fabric slightly stretchy (Figure 4-24); jersey and Lycra stretch regardless, even when cut vertically. Bias can be exploited structurally in spatial design in supporting rectangular frames from skew deformation. These experiences increased my practical knowledge of garment making and textile behaviour.

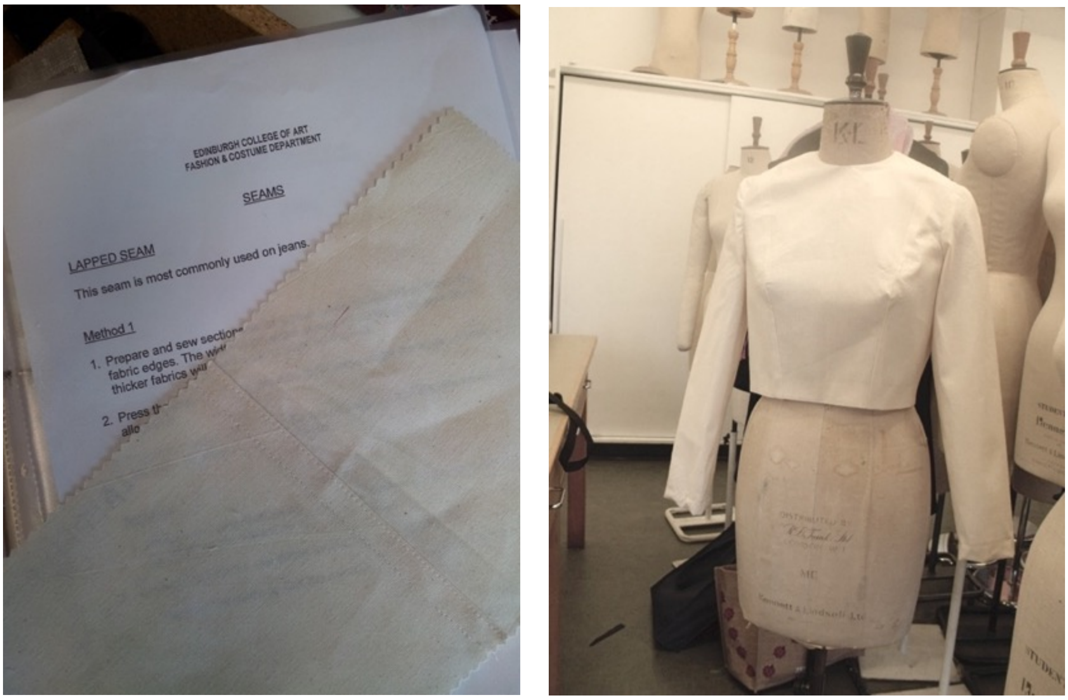


Figure 4-23: Tutorials undertaken during the pattern-cutting training course. Left: lapped seam. Right: bodice toile.

Figure 4-24: My experiment with grainline and bias line.

One stimulating tutorial was sleeve adaption, which explained various manipulations using simple techniques and pattern manipulations. These tutorials were inspiring concerning pattern cutting and supporting structures. From the knowledge gained on this course, I speculated on the potential applications of garment construction methods in spatial design; in particular, draping, pattern cutting and ribbing, which required further testing.

Reflection on the piloting stage:

Generally, investigations into creating a textile-based form between garment design and spatial design and its practicality revealed different approaches. The practical investigations described in this piloting stage, Section 4.1.2, served multiple purposes.

First, these investigations focused the research aim, which was broad. By testing the different possible routes for integration, many routes were excluded from the current research and shortlisted for possible future research. For instance, the investigations into sphere making related more to surface manipulation than to structure, and therefore suggested a refocus of the wider work. As a result of this pilot study, texture and material surface design and manipulation were excluded from this research (see Appendix 1, Section 1.9, pp.43-44) for surface and texture creation methods in garment making and texture organised into mind map and matrix). Additionally, several enquiries and comparisons were suggested for further research. These included garment pattern blocks vs. space orthographic drawings;

pattern blocks can be similar to projected drawings, as both are 2D drawings resulting in 3D forms. Thus, this begs the question: can we produce a standard pattern block for a textile-based space, such as would be produced for a garment? (Figure 4-25) For instance, in tensile fabric architecture, fundamental membrane shapes and patterns exist, such as the Barrel Vault (saddle) in tensile structure and the dome shape in inflatable structures (Koch and Habermann, 2004).

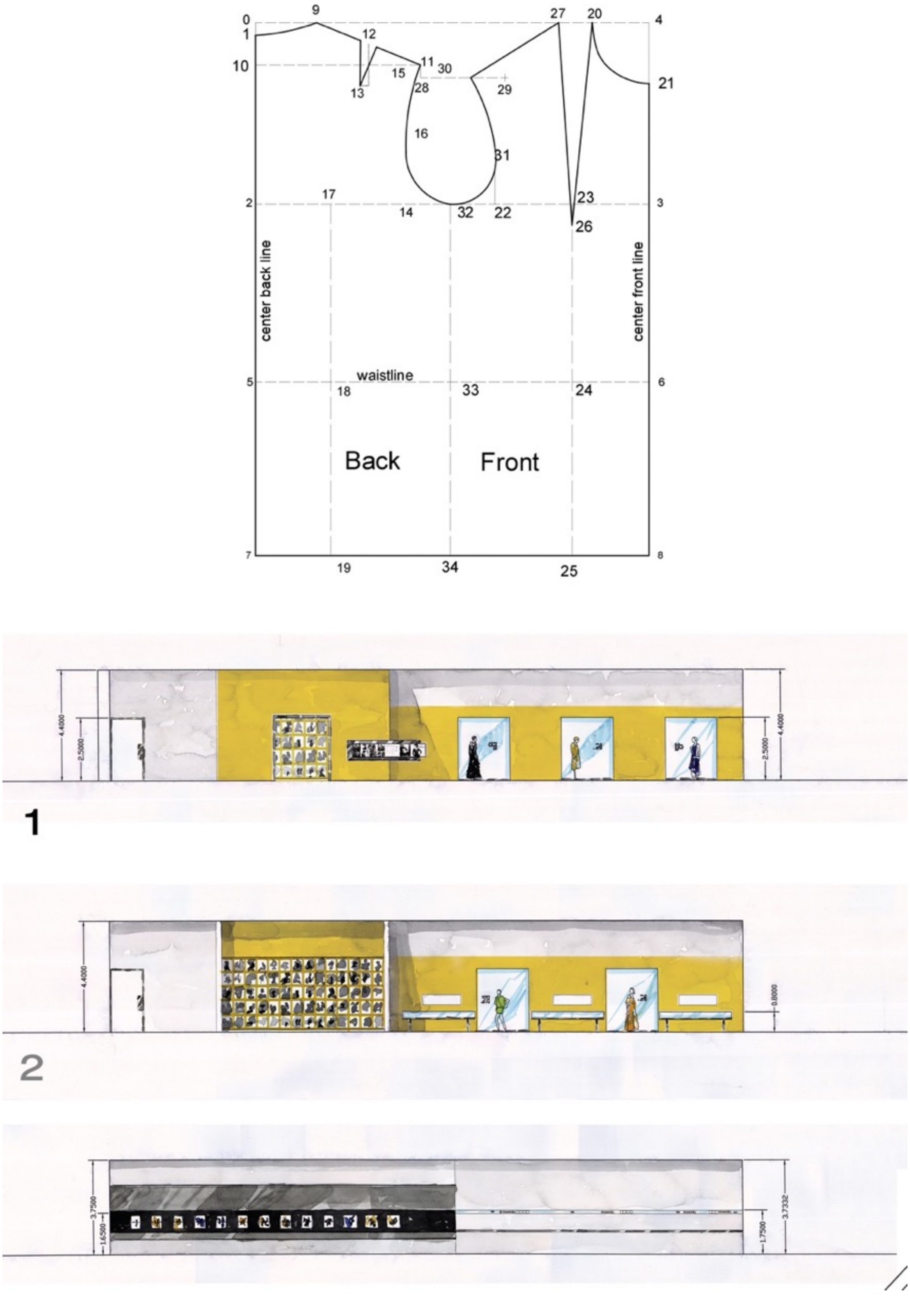


Figure 4-25: Garment pattern blocks vs. space internal elevations. Left image: Basic bodice pattern block drawing. Right image: Architectural use of orthographic projection drawings for interior environments. Image source: Author's work.

Second, scale, an important aspect of spatial design, was not addressed in this pilot study. While the sleeve was made—typical in garments—at actual scale (1:1), the sphere was unscaled. Instead, I made it small, with padding to give it shape; therefore, no constructional problem arose at this stage. Consequently, experimenting with actual materials on different scales was central to any further experiments. Additionally, it was important to maintain textiles' core properties, such as flexibility and weight, due to their significance in TSI space and construction.

Third, this stage helped to build practical adequacy by investigating 'through' practice how garment designers create garments, which contrasts with how architects and spatial designers create textile-based spaces using manual and digital tools.

Fourth, they enabled the piloting of the integration stage. I aimed to create suitable settings to stimulate and study the integration of the two practices in depth through a pilot study designed on a manageable scale. This pilot study indicated suitable methods, tools and materials to be used in a real-world case study during the next stage. For instance, investigations using digital tools would be limited to visualising and drafting, as further investigation into digital tools themselves requires separate research. These tools help to tackle the problem of large-scale structures using a combination of two programs (3ds Max and AutoCAD). Combining digital tools with physical tools and experimenting with materials on different scales is essential due to the current limitations of the software.

For more precise and focused research, it was necessary to plan future investigations and experiments for the purpose of design and fabrication of a defined TSI space. Furthermore, this would allow for continued practical investigations of materials and processes, of how integration may happen, and in which way it may transform textiles' use.

4.1.3 Design Project Stage

The ECA, similar to other colleges with fashion design departments, holds an annual fashion show to exhibit students' works. The stage space for the fashion show was a possible area for conducting practice-led research. However, the ECA exhibition stand emerged as another research possibility while negotiating this opportunity. This design, the relationship and links already established between two departments, and the opportunity to engage in practice within the communities of these two disciplines (students and tutors from both interiors and fashion) provided a fertile environment for research.

As explained in Section 4.2, I collaborated and coordinated with the interior design department at ECA and undertook the same design project as interior design students in the augmenting case study, following the same design brief (Appendix 5, Section 5.2). The stand was supposed to be freestanding, and fabricated solely with fabric and a pre-existing ECA aluminium frame system (Figure 4-26). However, I did so through a separate pathway—I did not interact with the students or see their designs at the initial design stage.

The design and fabrication occurred between February 2012 and March 2013. Developing the main design concept occurred between February and September, in parallel to the interior design students' design project timescale. However, the development, further explorations and testing occurred over an extended period, to achieve a full-scale design.

I visited the fashion design students' studio, inquired about their needs and preferences, and examined their designs. This gave me a better idea of the requirements for their exhibition stand. Additionally, I observed the previous year's exhibition stand design, which was composed of concrete—the opposite of the proposed stand for the current year, which was to be based on lightweight, foldable materials: mainly textiles and lightweight aluminium frames.

I conducted two informal interviews with the fashion design tutor and one of the fashion design students[26] about the process of garment design the fashion design course. I provided the interviewees with a mind map of the design and fabrication process of a garment, and requested they draw their own (Appendix 4, Section 4.4, pp.104-105). This interaction was a useful source of additional knowledge to that obtained from reading. I observed, interviewed and interacted with fashion and costume design students, tutors and technicians; studied and made objects; and studied the design processes of individuals and groups.

[26] I interviewed this student as his designs were sculptural garments

Figure 4-26: ECA exhibition system metal structure.

Design Activity 1: Hands-on experimentation with Lycra attached to a bearing frame, concept development

I employed part of a Lycra piece as a space divider/partition in two distinct positions and observed its behaviour. The first position was fixed (attached to a frame). The piece showed a tendency to twist, showing that fabric flexibility and its tendency to drape and hang under the force of gravity is the main factor in later achieving a freestanding and balanced piece (Figure 4-27).

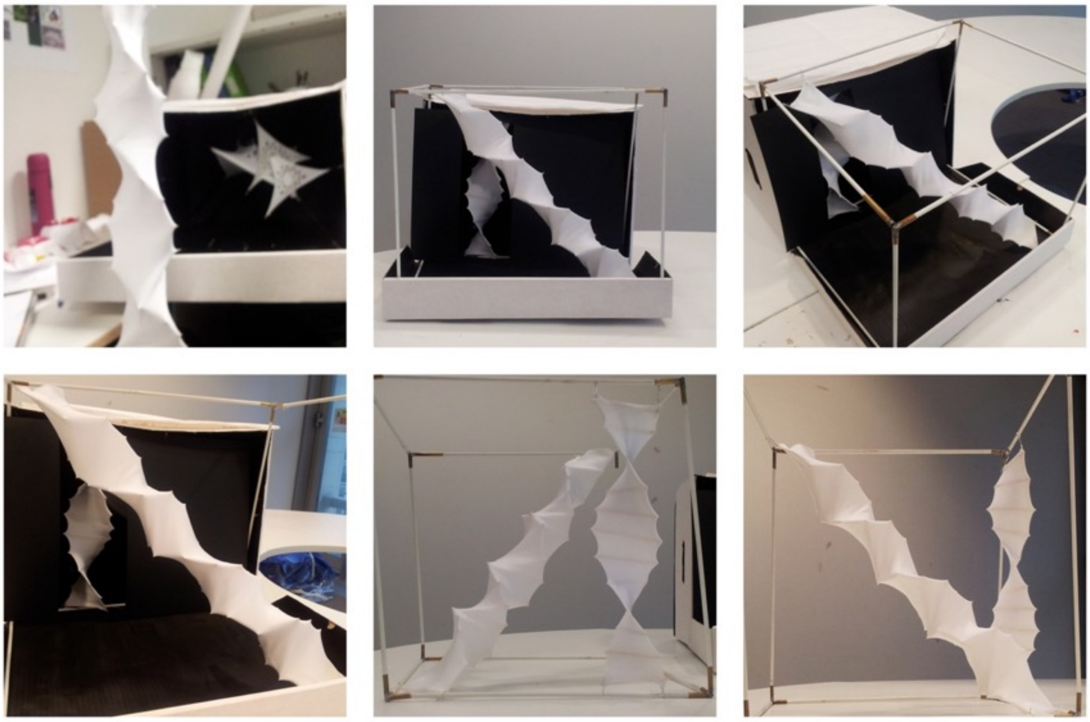


Figure 4-27: Employment of ribbed white Lycra as a space element.

Design Activity 2: Hands-on experimentation: achieving a self-standing Single Twist space divider using draping and boning

While playing with the Lycra piece, trying to achieve a freestanding position, I realised that if the piece was fixed in the middle, the other two ends could drape on the floor, thus achieving balance and stability (Figures 4-28 and 4-29). According to the design brief, it was necessary to achieve a freestanding position, where the stand remained unattached to any of the accommodating space elements. Since the developed freestanding form showed a potential application in spatial design, further tests on larger scales were required. This freestanding form was used as a space divider and as the base concept for the whole exhibition stand design.

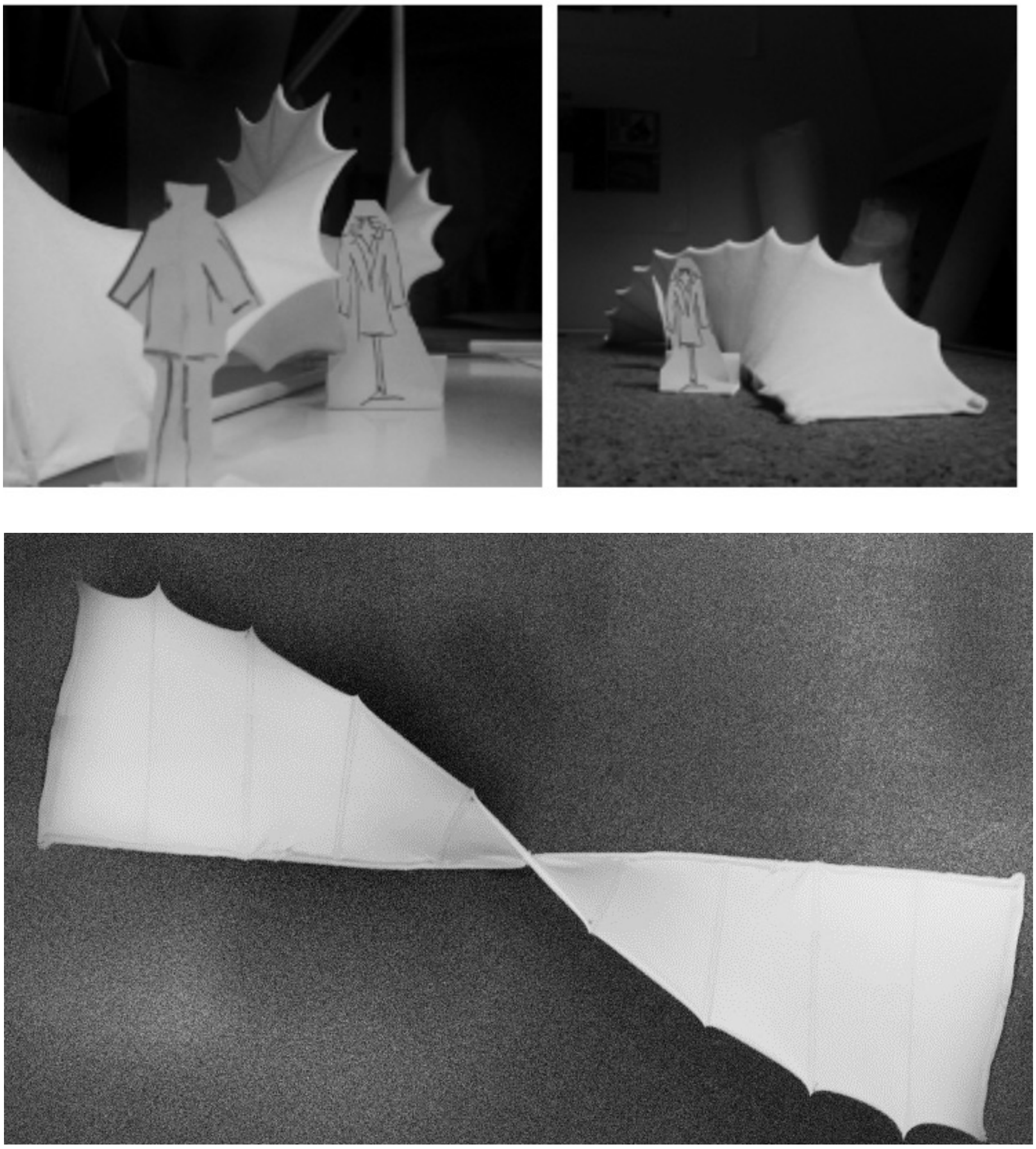


Figure 4-28: Employing a ribbing/boning experiment as a space divider. Top left: the piece attached to a frame. Top right and bottom: the self-standing piece achieved.

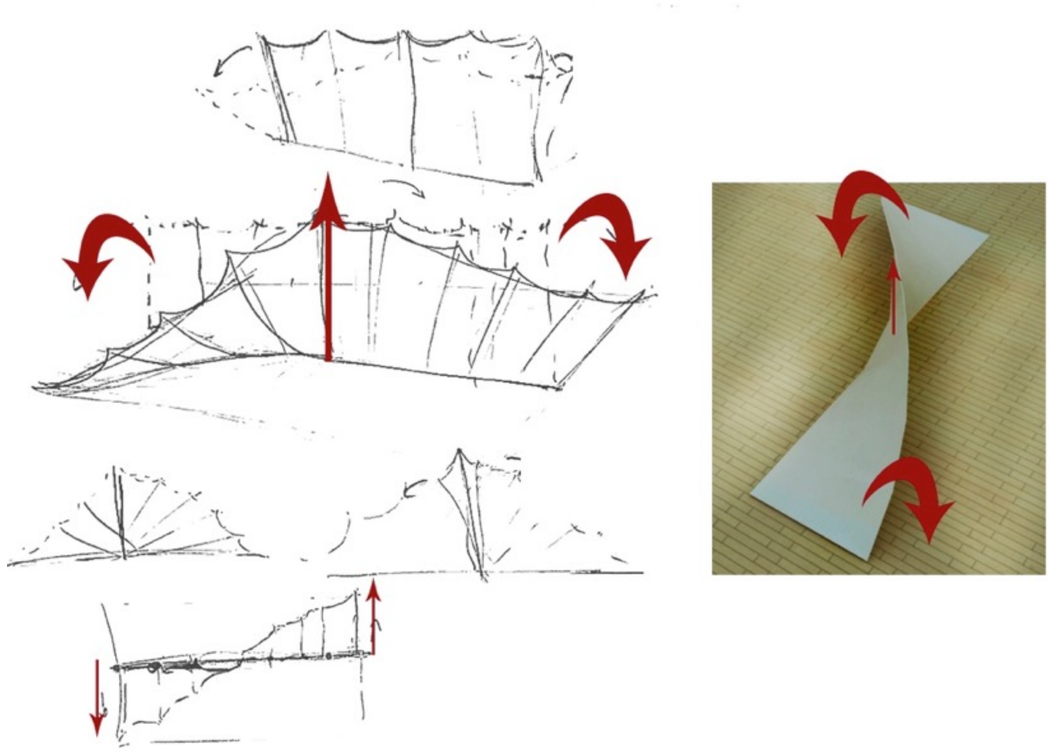


Figure 4-29: The two ends of the model drape in opposite directions to achieve a stable form, using the boning/ribbing method and fabric properties to drape.

Design Activity 3: Digital modelling of the Single Twist space divider and the whole exhibition stand design

The exhibition stand design was based on the space divider model (single Lycra twist) achieved in practical experiments. Creating a model at a large enough scale for the whole space was unachievable (for me). Therefore, I followed a conventional architectural approach and designed the whole space abstractly. I used digital tools (AutoCAD and Autodesk 3ds Max Design) to model the design. The process began by simulating the Lycra piece on the computer. The final stand design was made of two pieces intersecting at right angles to create a cross. This design shape was used due to practical considerations: it created a simple background to display students' work equally within the space (Figure 4-30).

I used mesh/polygon modelling, which is a powerful system for modelling in Autodesk 3ds Max; I also have strong experience with this modelling type.

However, the piece appeared as a solid object and did not reveal the fluidity of the fabric's surface. This was because using polygons can make it more difficult to create complex curved surfaces—meshes are faceted, and these facets appear at the edge of rendered objects. A large number of small /polygons is necessary to render a smoothly curved edge.

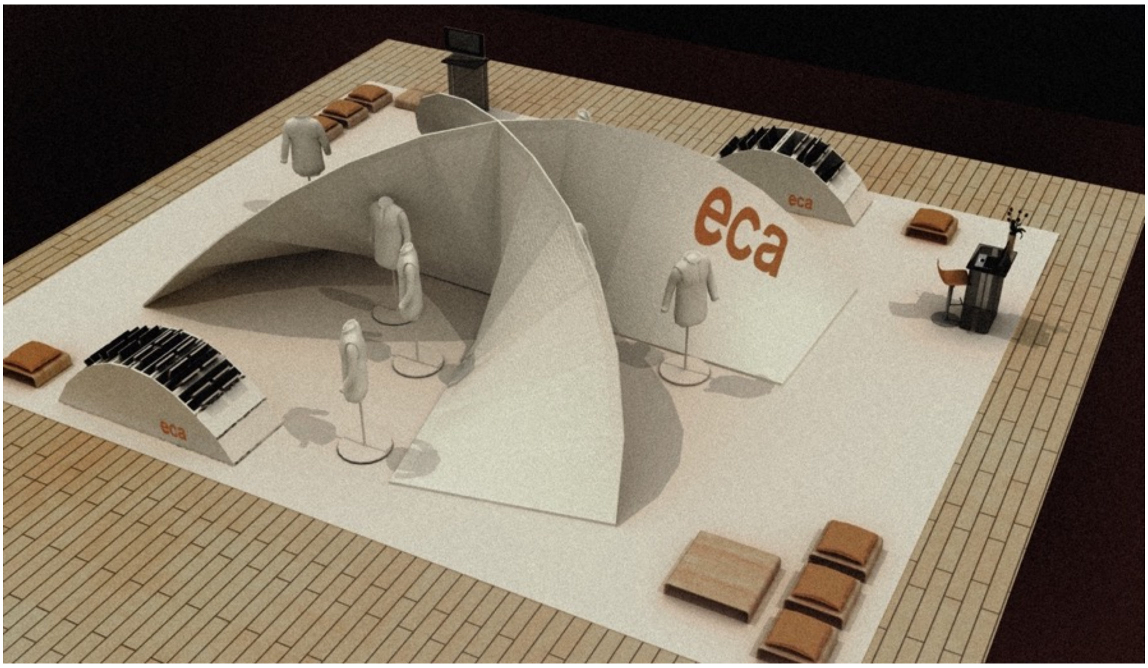


Figure 4-30: Conceptual design of ECA stand in 3ds Max Studio. CGI Image source: Author.

Design Activity 4: Digital design exploration of the Single Twist space divider

During further explorations of possible forms of the space divider in CAD, I modified the digital model of the Single Twist using simple modifiers such as Twist and Bend. I achieved two additional forms of the single twist: a Circular Twist and a Double Twist (Figure 4-31).

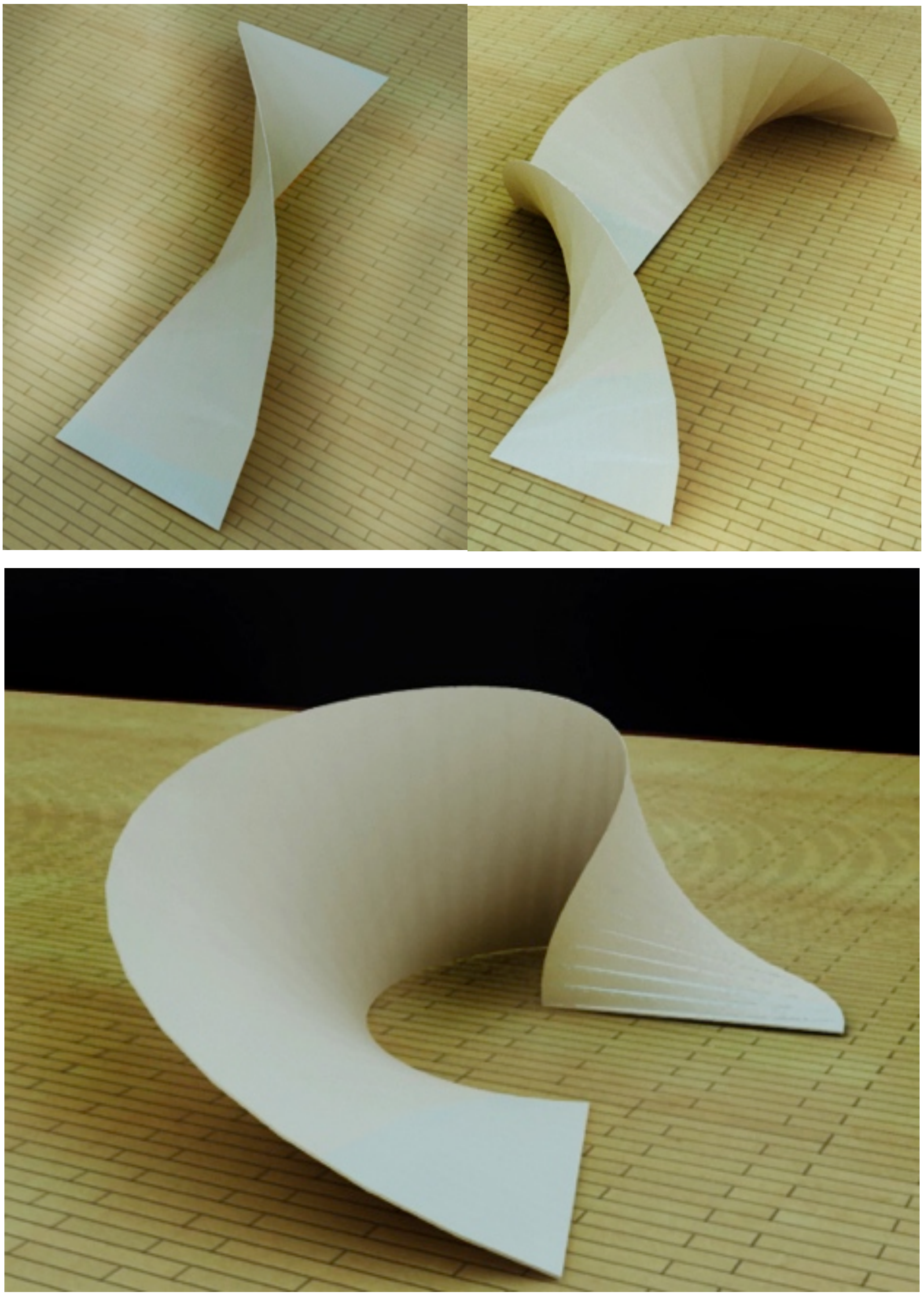


Figure 4-31: Conceptual Single Twist options using 'Bend' and 'Twist' modifiers.

Experimenting with digital tools facilitated a different type of exploration from that offered by physical experiments. Digital tools facilitated fast and smooth expansion of form explorations. For instance, it would have been nearly impossible to bend the original Single Twist physical model into a circle in the same smooth and fast manner enabled by digital tools.

After achieving three forms for the space divider using digital exploration, I moved to the physical modelling stage to test these forms structurally. I utilised my expertise in interior design to make physical models on different scales—an architectural method. However, this model making required a specific set of information, which differs from conventional architectural drawings (plans, sections and elevations) typically used in fabrication.

Design Activity 5: Digital 2D patterns from three space dividers

Conventional architectural orthographic projections (planes, elevations and general dimensions, such as the width and height of flat surfaces) were not adequate for fabricating this design (Figure 4-32).

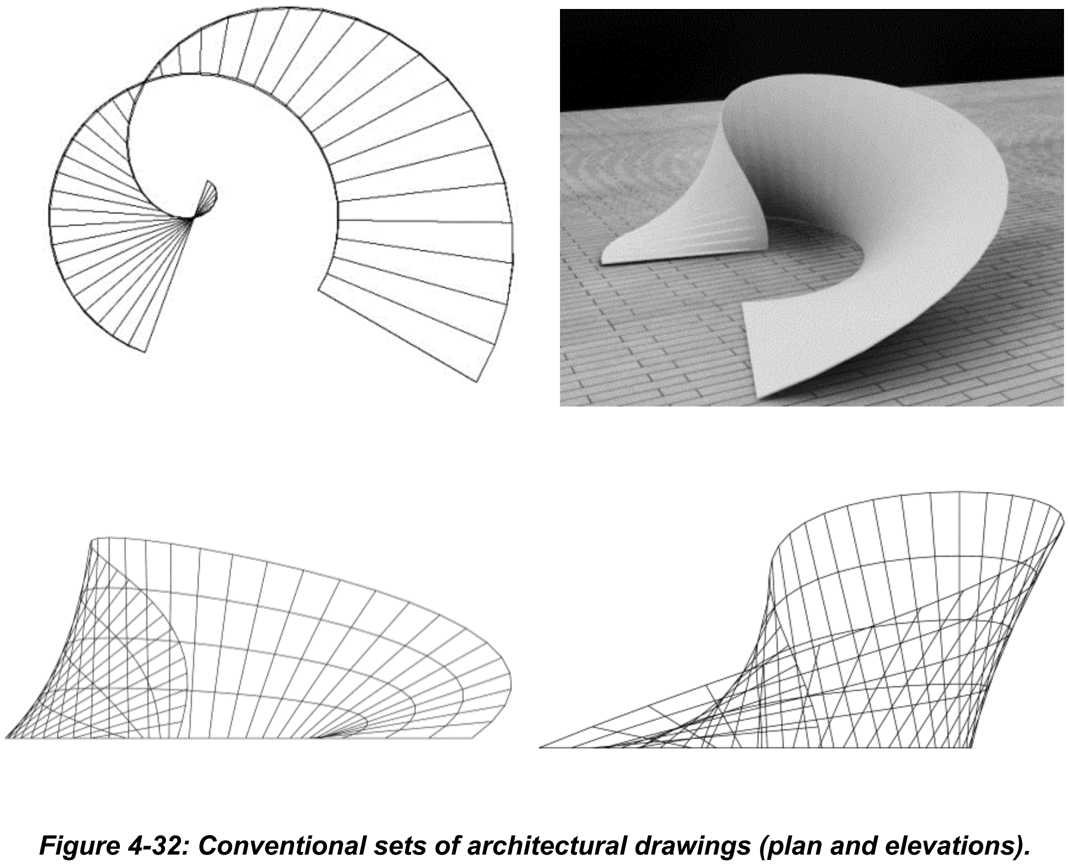


Figure 4-32: Conventional sets of architectural drawings (plan and elevations).

For this reason, 2D patterns were required to fabricate these nonlinear models. As shown in Chapter 2, designers develop patterns using three methods during the garment design process: flat pattern design, drafting and draping. These require body measurements of some sort, or pattern blocks. Alternatively, in tensile fabric architecture, special software creates patterns for any tensile fabric structure. I could not use garment design approaches, as I had no standard pattern blocks, nor a body with known measurements, from which to start. Neither could I use tensile fabric architectural software, as my models did not follow the principles of tensile structures.

However, my experience in architectural software (in particular, 3ds Max and AutoCAD) inspired a method of pattern development. ‘Unwrap UVW’ is a texturing modifier in 3ds Max, but it also can flatten parts of model texture to be mapped more easily (Autodesk, no date d). I adapted this modifier to attain flat patterns of a 3D digital model (Figure 4-33). This method is efficient at developing patterns in digital format to be either printed onto paper, or cut into fabric using a laser-cutting machine.

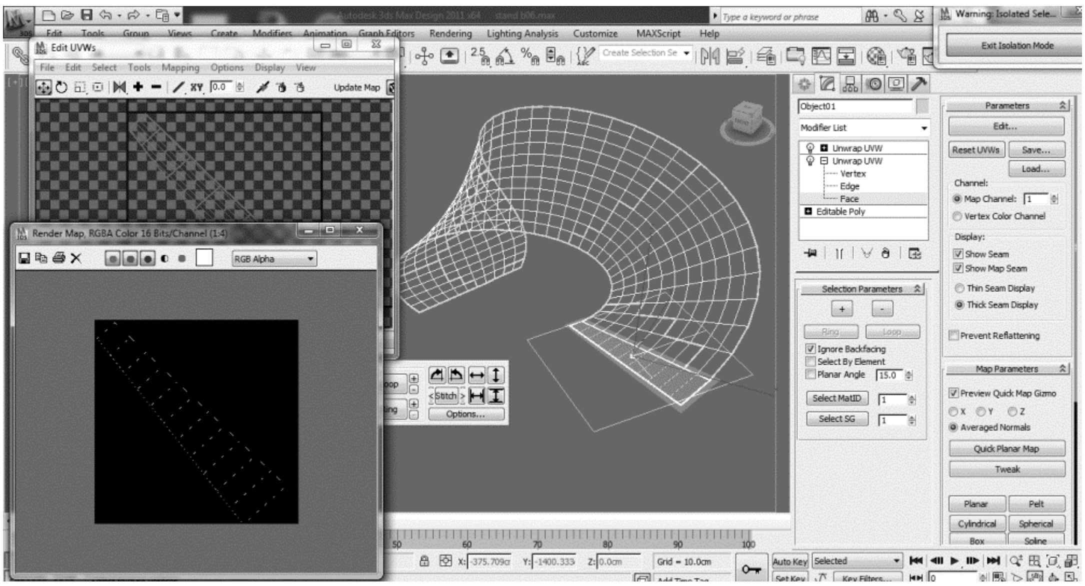


Figure 4-33: Finding patterns using the ‘Unwrap Map’ modifier.

However, patterns generated by the ‘Unwrap UVW’ modifier were made from quadrilateral-shaped units, not positioned in an ordered manner, and overlapping in some places. They required manual manipulation to achieve continuity (this reduces waste when they are transferred to fabric). I used my expertise in pattern cutting to re-order these units using 2D architectural software (AutoCAD), and relocated them to create a continuous piece (Figure 4-34).

Although 3D software such as 3dsMax can provide 2D patterns of a 3D form, it does not provide important timesaving details, such as panel numbers, seam allowances and other markings (notches), which have to be added manually. Since the ‘Unwrap UVW’ modifier is normally used for digital models (not for fabrications), further adaption of digitally generated patterns was required, such as adding seam allowance and notches for assembly.

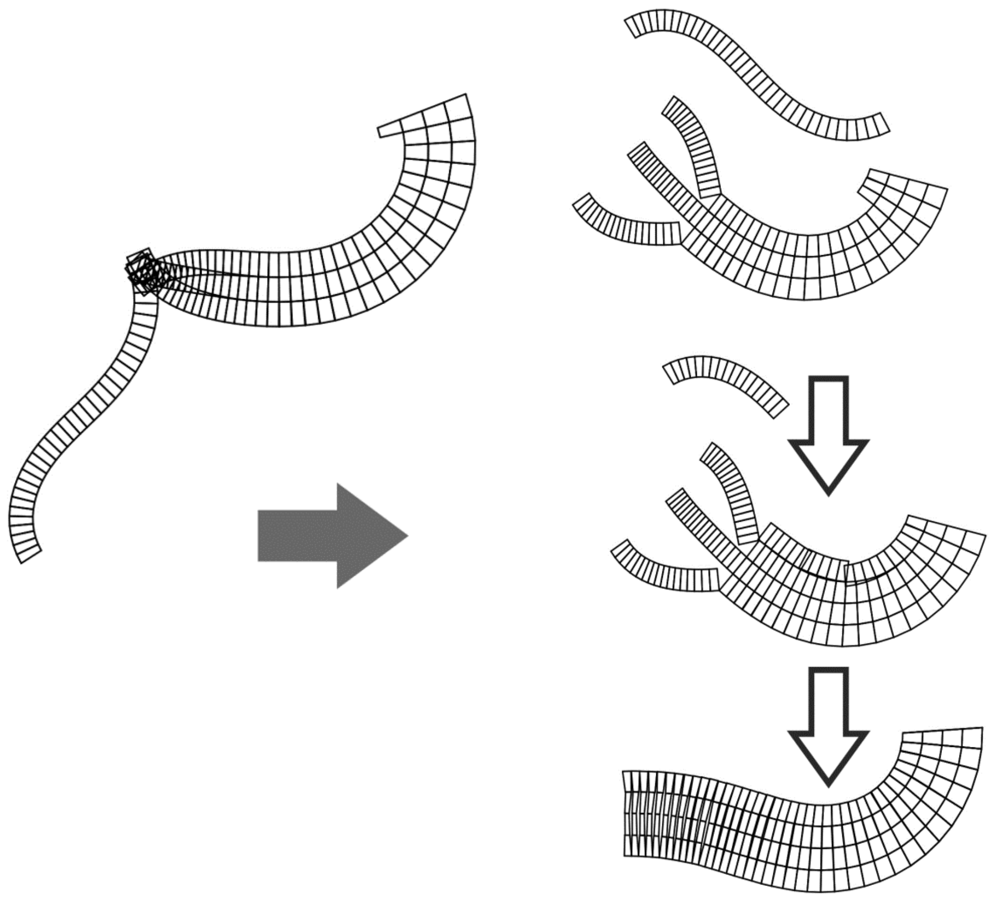


Figure 4-34: Pattern manual correction using AutoCAD.

Design Activity 6: Hands-on paper model making, scale 1:50

Physical models were required to investigate the process and to test the ribbing method. Paper models of scale 1:50 were made to test the digitally extracted patterns (Figure 4-35). This step was the first that showed the differences between digital and physical models regarding their details and stability.


Single Twist Space Divider Model
:1/50

Figure 4-35: Paper models, scale 1:50.

Design Activity 7: Hands-on fabric model making, scale 1:5, and pattern testing

Thereafter, fabric physical models were made to test these issues on larger scales. Three models were built at scale 1:5 with three fabric types: two unforgiving types, Calico and Tyvek, and one stretch type, Lycra. These three types were selected based on the piloting stage (Subsection 4.1.2). Lightweight materials were used for boning/ribbing: for instance, lightweight fibreglass rods, and ERW tubing, an ideal choice when the strength-to-weight ratio is critical.

I experimented with two methods of transferring these model patterns onto fabric to be cut. The first method was used for the first two models (Double Twist made from Tyvek and Circular Twist made from Calico): digital patterns were printed on paper, traced with the required details such as seam allowance, and cut manually (Figure 4-36).

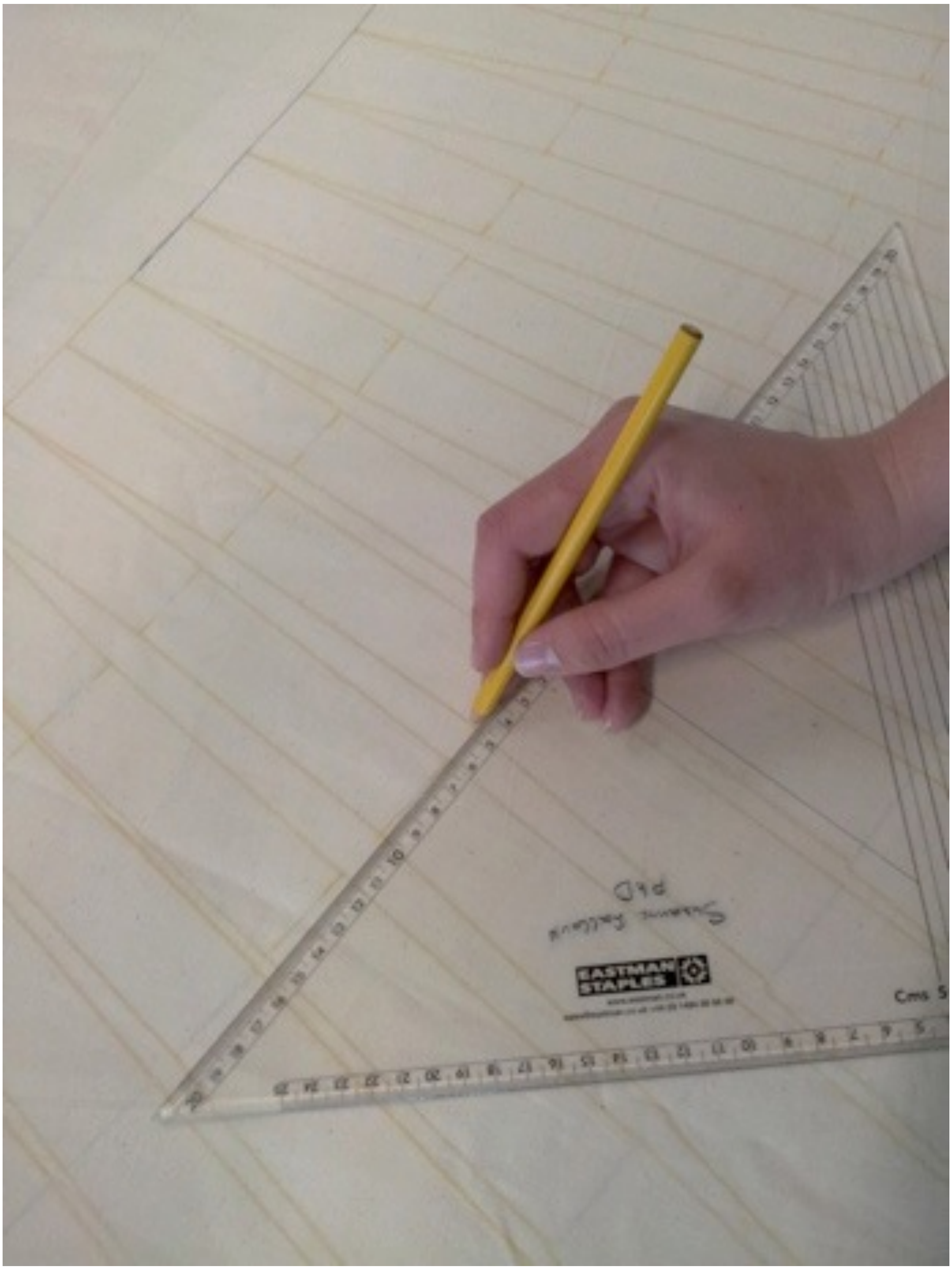

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Figure 4-36: Top: printed patterns on paper (Double Twist Tyvek model). Middle: tracing printed paper patterns on Calico (Circular Twist model). Bottom: cutting the fabric patterns manually (Circular Twist model).

In the second method (used for the Single Twist composed of Lycra), digital patterns were cut directly using a laser-cutting machine (Figure 4-37). The second method was more practical and efficient, as it was faster and did not require the manual labour of tracing the patterns on paper, then cutting them.

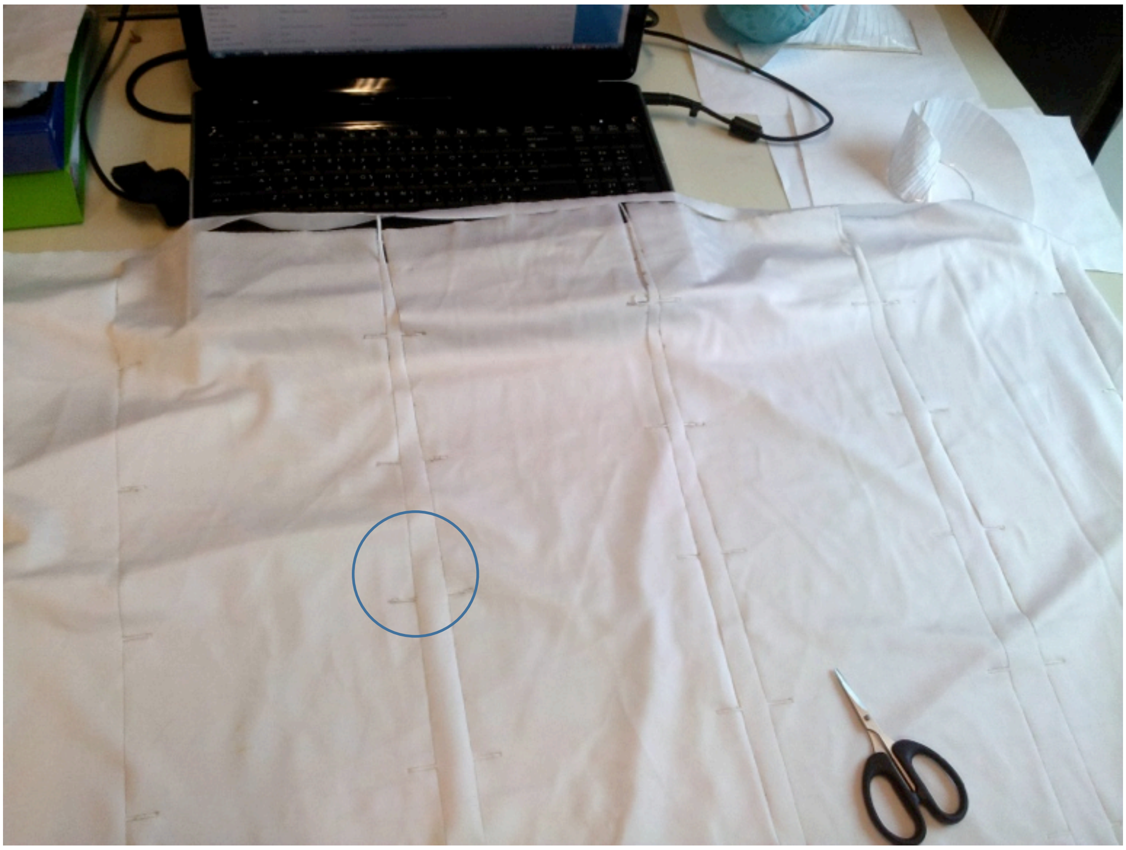
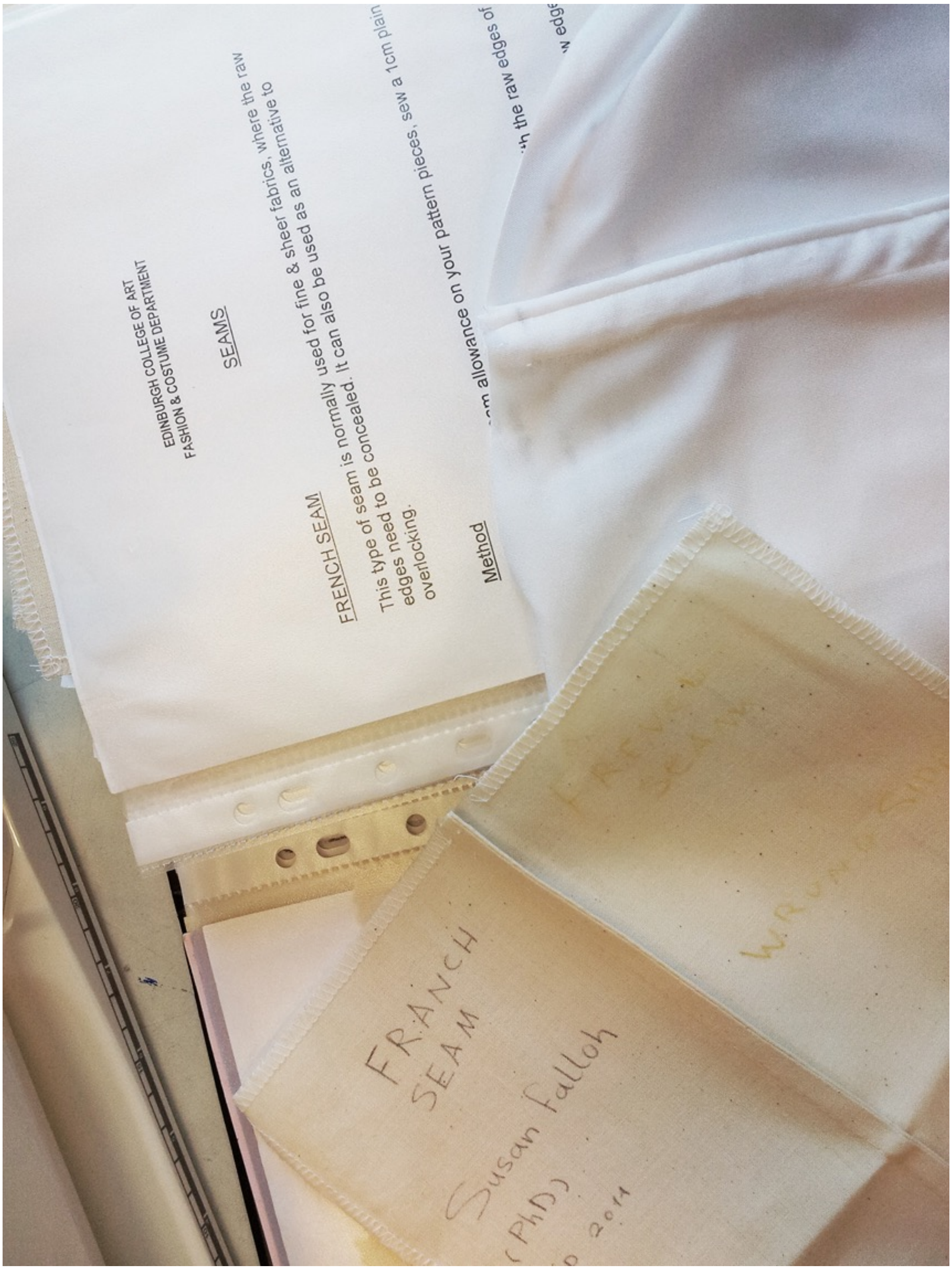


Figure 4-37: Lycra patterns cut using a laser-cutting machine with assembly details (notches and seam allowance).

After preparing the fabric patterns, I used my newly-acquired knowledge of sewing, pinning, the use of darts and stitching using different seams to join fabric patterns and integrate the bones/ribs (Figure 4-38).


EDINBURGH COLLEGE OF ART
FASHION & COSTUME DEPARTMENT
SEAMS
FRENCH SEAM
This type of seam is normally used for fine & sheer fabrics, where the raw
edges need to be concealed. It can also be used as an alternative to
overlocking.
Method
FRANCH SEAM
(PhD)

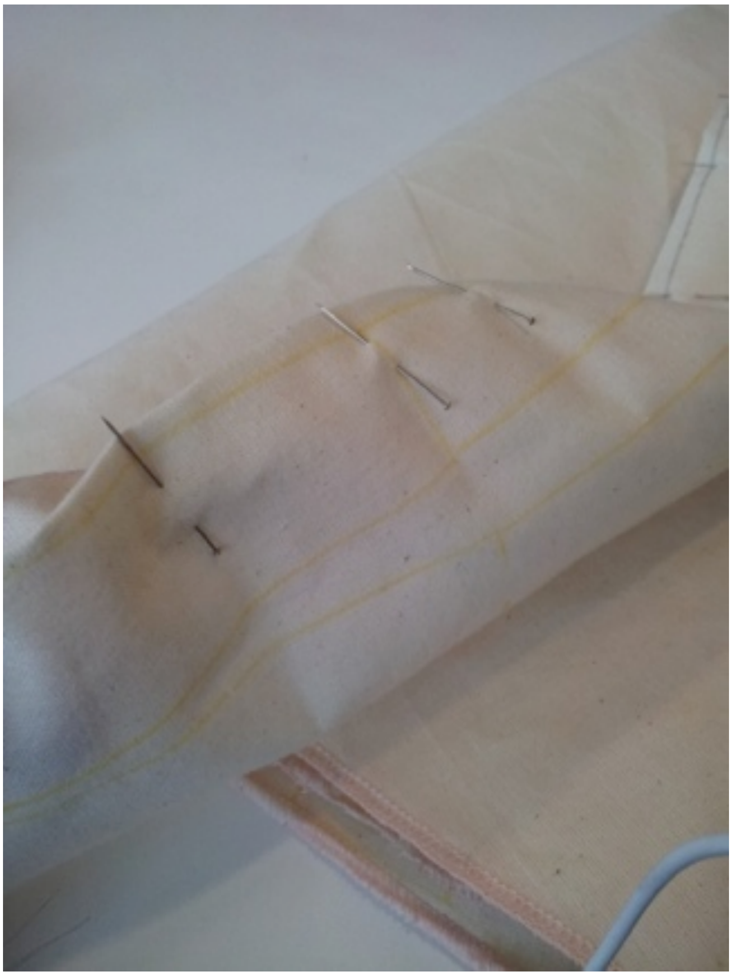



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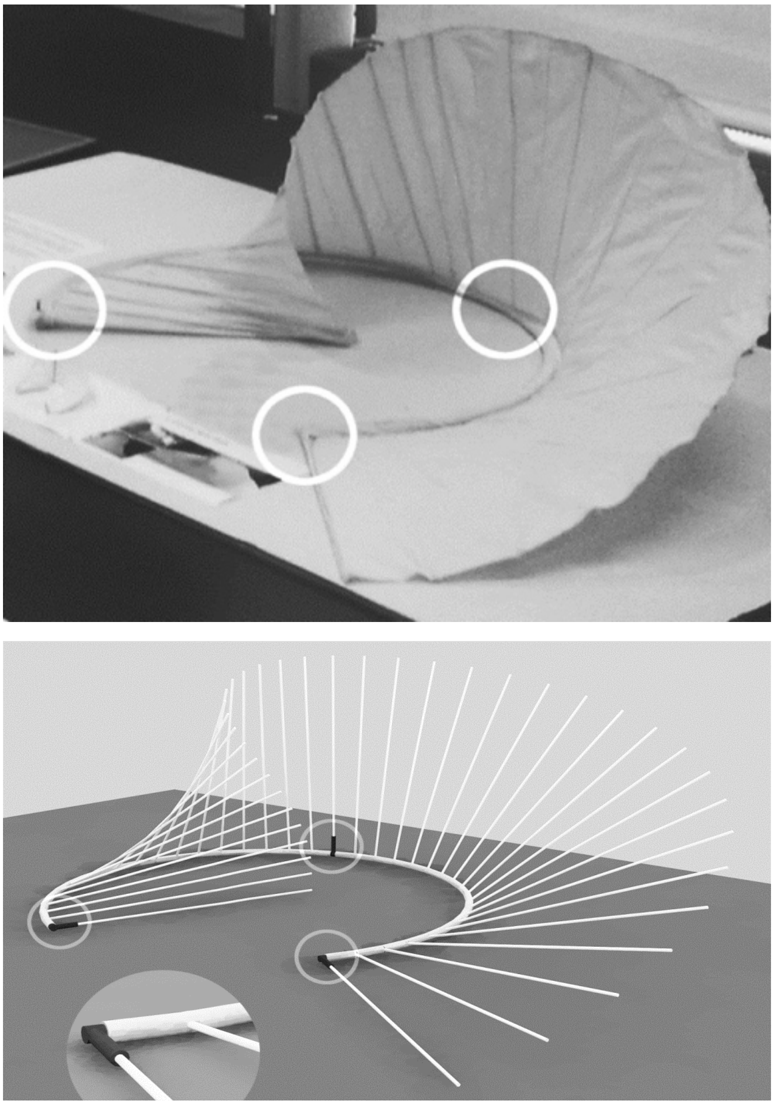
Figure 4-38: Stages of pinning and stitching darts, experimenting with different seams to achieve the final shape for the fabric pattern of the Circular Twist model.

To ensure that this realised model was stable against disturbance (change in position or orientation under external force), I added three fixed joints between the main metal rib and three of the secondary fibreglass ribs (at the middle and both ends) (Figure 4-39), while the rest of the ribs were inserted into channels created through seams between the fabric patterns.



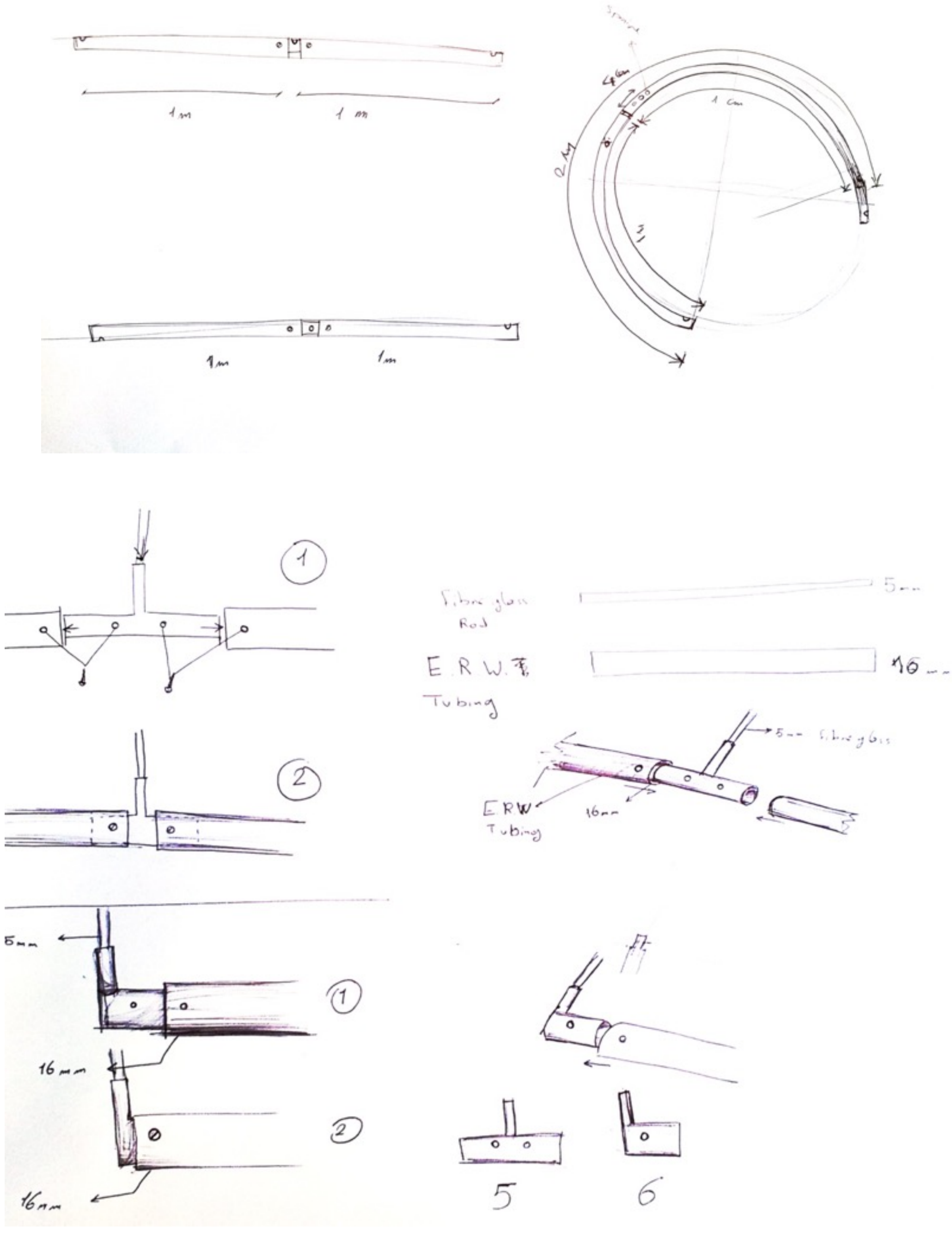


Figure 4-39: Three joints were required to ensure the model was stable against external disturbance.

These models showed creasing on the fabric surface when unforgiving fabric types such as Calico and Tyvek were used; the Lycra model had a better fit and finish (Figure 4-40, left image).

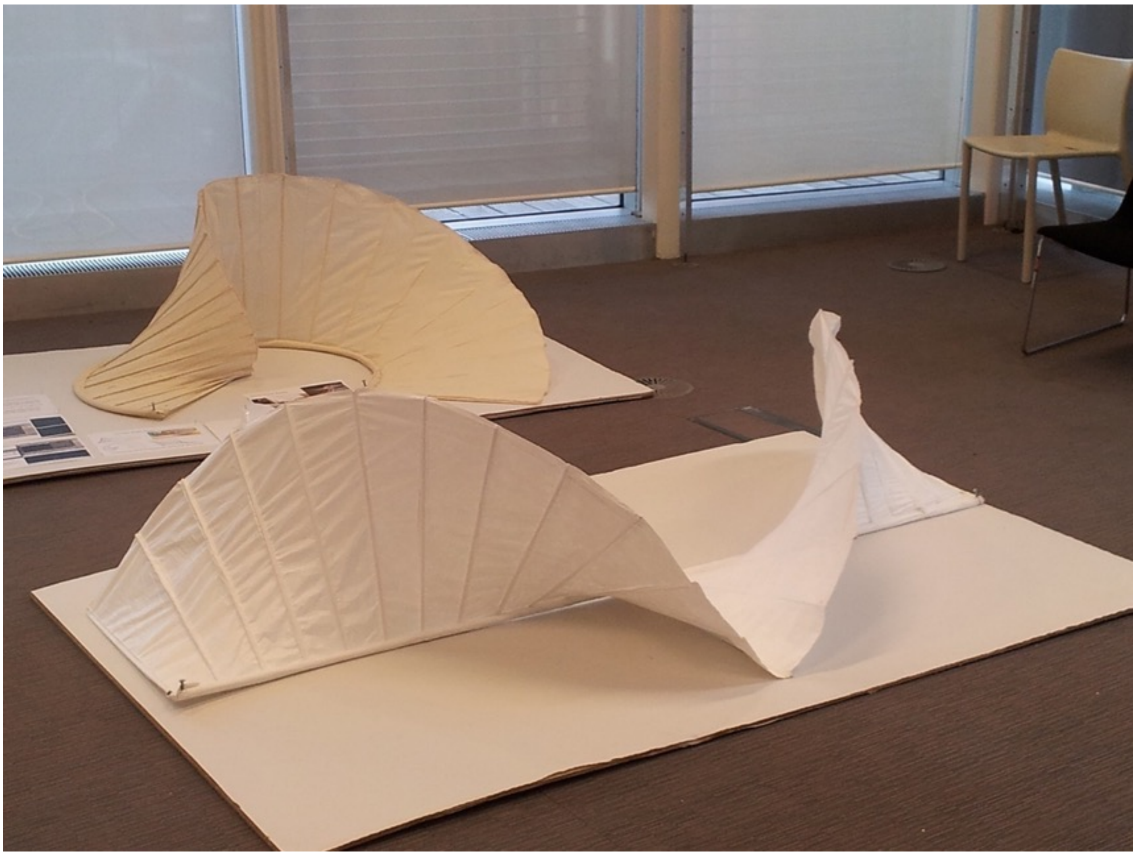


Figure 4-40: The three fabric models, scale 1:5 (Calico, Tyvek and Lycra).

Design Activity 8: Hands-on fabric model-making, scale 1:1

Finally, investigations with full-scale models examined the design and efficiency of the ribbing method in construction. As building the whole stand model at scale 1:1 was unachievable (for me) and beyond the available resources and timescale, I fabricated part of the space divider (Double Twist) developed in previous experiments (Figure 4-41).

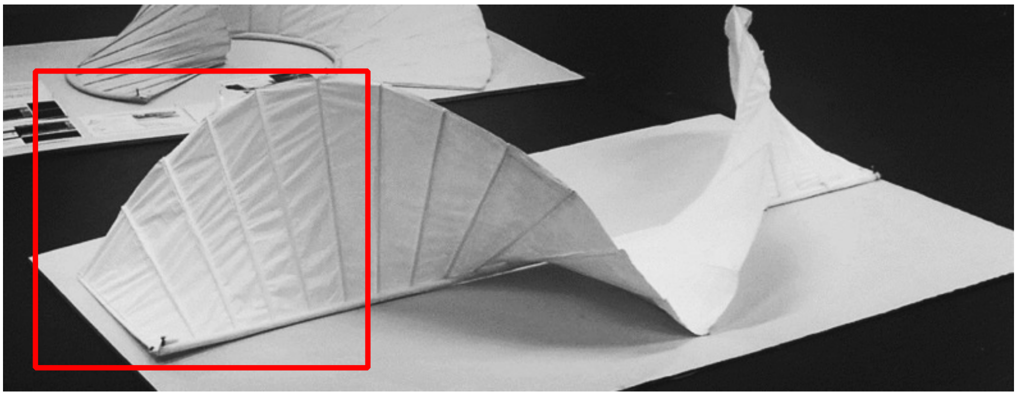


Figure 4-41: The whole space divider (Double Twist) model at scale 1:5; only the area in the red square was fabricated at scale 1:1.

In terms of material choice, Lycra is not the lightest of fabric types, but it was selected as a forgiving fabric with considerable stretch. Consequently, it hangs better on a supporting structure with a better finish (no creasing), which was an issue with other model materials at scale 1:5 (Figure 4-40).

The digital patterns used in the model at scale 1:5 were re-scaled to 1:1; re-scaling the patterns was an easy, one-step process in AutoCAD. The patterns were then cut out using a laser-cutting machine. Lycra was more challenging to sew than other fabric types. When trying to stitch the edges of two panels, they slipped—it was hard to keep these edges together while using a standard sewing machine (there are specialised machines for sewing Lycra in the industry, but these were not available). Therefore, initial hand stitching was required to solve this problem and keep the edges together (Figure 4-42).

Figure 4-42: Hand stitching was conducted prior to machine stitching to keep the edges of patterns together and prevent slippage.

Design Activity 9: Hands-on and digital finishing details

The physical models revealed structural elements missed by the digital models. Again, I used my expertise in architectural detailing to design the required joints. Similarly, I used my new-found garment design expertise in pattern cutting, sewing, darts and seams to fabricate these models and add necessary fabric-related details.

In terms of detail, differences between modelling and built work are a critical, inherent part of the design process: as Ludwig Mies van der Rohe suggested, “God is in the detail” (Stacey, 2005). Generally, issues with structural body stability and details, such as joints, seams and darts, emerged as the physical models became larger in scale and were made of materials (fabrics) rather than paper; consequently, they were heavier. The process of building the models and the aspects of each individual model provided a better understanding of these structural issues.

For the ribbing/boning, seven flexible polypropylene tubes (secondary ribs) and two aluminium poles (main structure) were used. For the joints, five bespoke, part-restricted T aluminium joints were fabricated in addition to two fixed L-shaped joints (Figure 4-43).

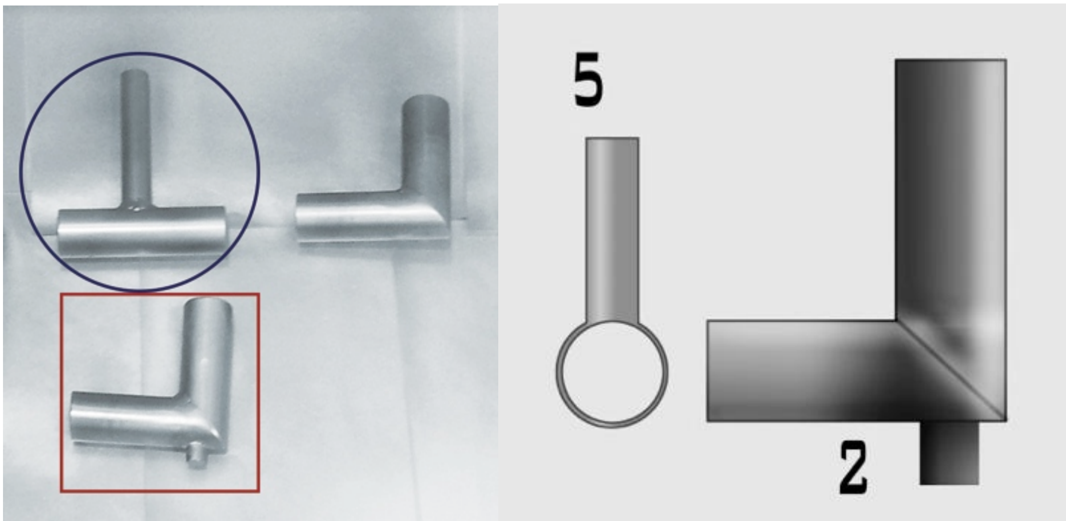


Figure 4-43: Details of supporting structure comprised of boning/ribbing and different joint shapes.

The tubes’ and poles’ straight-cut ends failed to provide a neat finish. Therefore, a bespoke 3D-printed finishing detail (bullet-shaped) was designed and fabricated. Creating this detail involved manual and digital tools. First, a clay model was hand modified to achieve a suitable form. This initial model helped with sketches and measurements on paper (Figure 4-44).

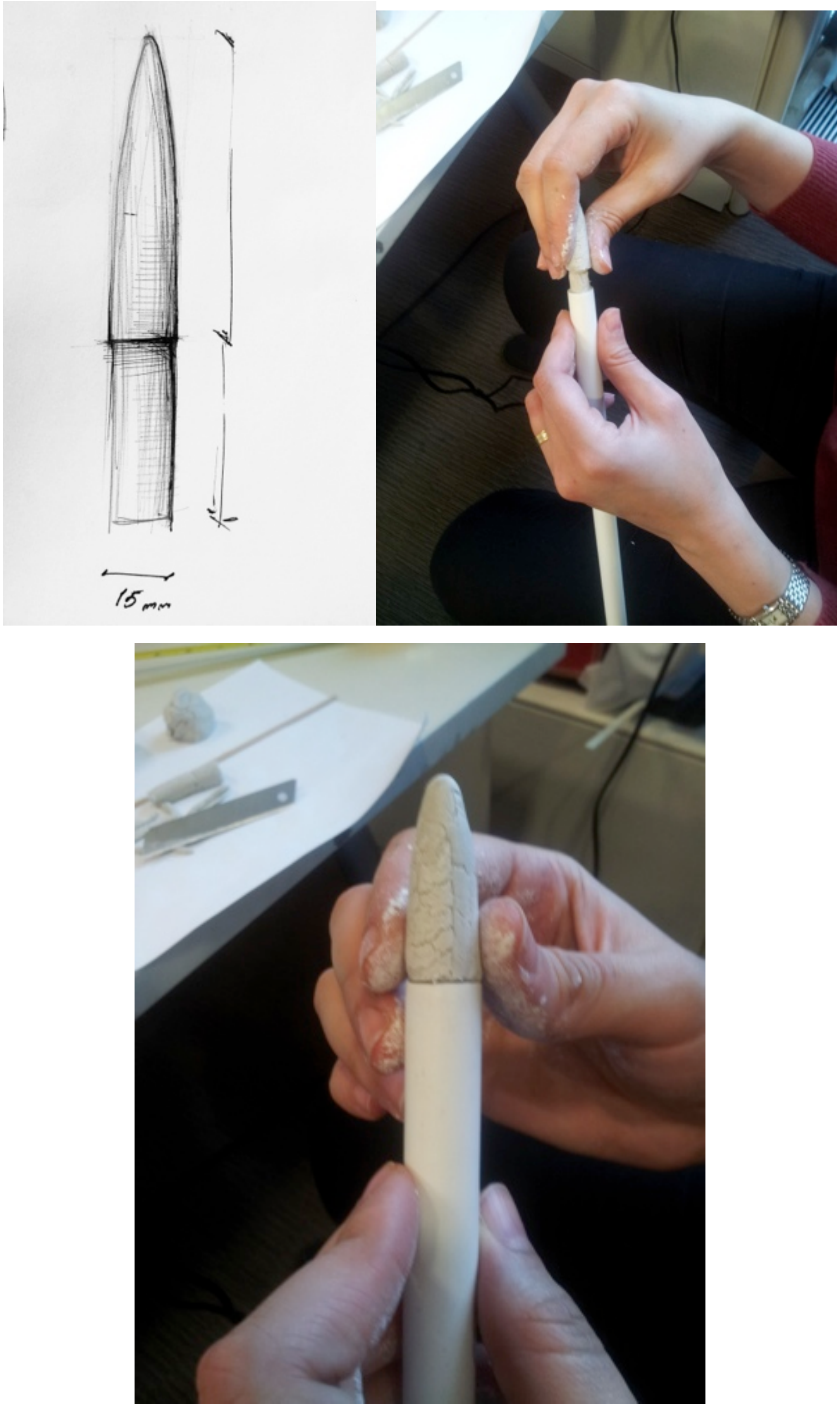


Figure 4-44: Right: clay model making. Left: bullet sketch.

The piece was drawn in 2D using AutoCAD, then transferred to 3D using 3ds Max, where digital models were produced in two sizes: one for the polypropylene tube, and the other for the aluminium pole. These digital models were then 3D printed (Figures 4-45 and 4-46).

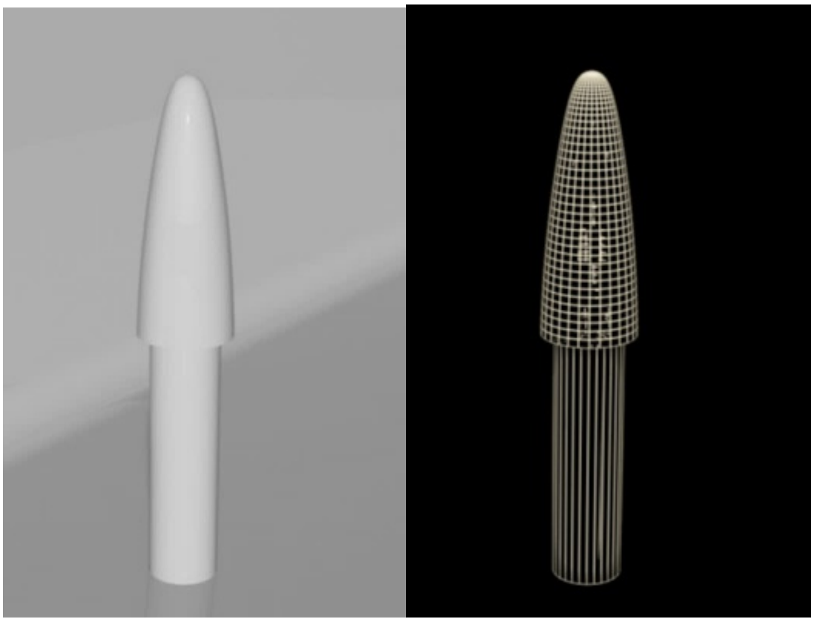


Figure 4-45: Right: a 3D digitally rendered model of the bullet-shaped detail. Left: a 3D digital model of the bullet-shaped detail in wireframe view.

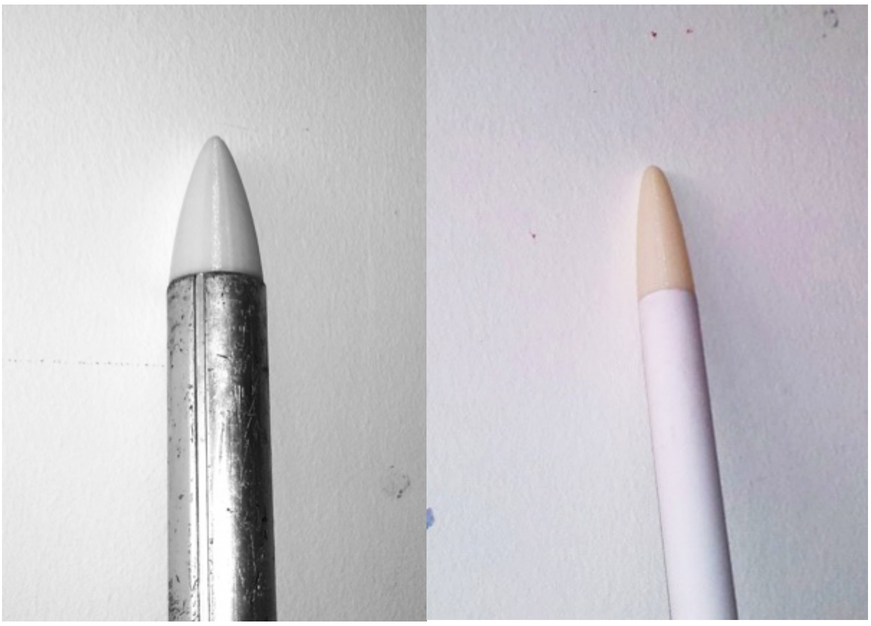


Figure 4-46: Bullet-shaped detail. 3D-printed models in two different sizes.

Other finishing details were created. For instance, the waistband detail stitched by hand during the installation was used as a channel to cover the bottom rib (Figure 4-47).

Figure 4-47: Installation process. Left and middle: inserting ribbing into the sewn fabric channels. Right: finishing the waistband detail to cover the bottom rib, using hand stitching.

Once achieved, the final model part at scale 1:1 (Figure 4-48) provided a different result from the previous scaled models. It presented the outcome of the whole design and fabrication process for Case Study 2, and provided rich material for comparison and analysis (see Chapter 5).

The final actual scale model (Double Twist space divider) offered the best material for examining the outcome of this design activity regarding its form and structure, while the whole process of designing and fabricating the models (digital or physical) on different scales and their images was an important source of data for studying the process, as I used comparison as a main analysis tool.

Fabric and ribs balanced each other differently according to scale: at scale 1:1, the flexible ribs/bones contrast with the rigid rods required at scale 1:5. Flexibility enables ribs/bones to move, creating a fluent form. Thus, fabric and ribs create balanced structure, working with forces that can be seen, but not fully understood by a non-specialist audience. Yet, from a structural and engineering perspective, the influence of these affecting forces can be calculated and analysed.

We should note that scaling fabric thickness is an issue when working with scaled models, as the thickness of a certain type of fabric cannot be changed. Some architects use thin versions of fabric in their scaled models, some even repurposing fabric such as tights for this use. However, these do not behave in the same way as the final fabric.

Figure 4-48: Finished model, scale 1:1, front and back view.

In principle, all three models achieved the desired form through two main methods: boning/ribbing and draping, which exploit fabrics' flexibility and ability to hang and drape under the effect of gravity. Fabric was supported with bones/ribs channelled in fabric and connected to a base bone/rib with partly restricted joints. Only the middle rib/bone was fixed in a perpendicular horizontal position; the two end bones hung and draped at the two sides of the model in opposite directions. The remaining ribs were carried by fabric and followed its draping direction under its own weight. The joint at the two ends could be fixed to secure the model from external distortion.

Interestingly, the bones/ribs and fabric supported each other to achieve structural integrity: neither of them could stand alone.

4.2 The Augmenting Case Study Strategy

The prospect of studying an experimental design activity with a group of design students was an opportunity that emerged whilst conducting this research at the ECA. It emerged because the existence of departments and workshops in fashion, textiles and interior design—all covered by the ECA—was an essential requirement for the setting of this interdisciplinary research; research that would be rooted in the implementation of my own practice in research and across disciplines. In this context, I collaborated and coordinated with the interior design department at ECA to conduct research within the curriculum and establish connections between the interior and fashion design departments through a workshop linked to an interior design semester project. The University has an annual Innovative Learning Week as part of the curriculum; for this event, staff and researchers (including PhD students) organise voluntary workshops that celebrate creative learning. Collaboration with interior design tutors on a third-year undergraduate interior Design course led to the organisation of a workshop in February 2012 for Innovative Learning Week. It resulted in collaboration on a semester project involving the design and fabrication of an exhibition stand to showcase ECA fashion design students' work during Graduate Fashion Week 2012.

The exhibition stand is a real-life project implemented as part of the third-year undergraduate interior Design curriculum. interior and fashion design departments collaborate: the Interiors students design and build an exhibition stand to exhibit the work of the fashion students. The working relationship between the two groups used to be a designer-client relationship. However, the research aim of this thesis implied the pursuit of a different type of relationship: one of interdisciplinary practice and learning. The intention was that Interiors students would use garment design methods to design and construct the stand, while fashion students would advise and tutor them on the use of textile and garment design methods.

Additionally, the cross-discipline approach was perceived by the two departments to have beneficial implications for students’ teaching and learning by informing them of textile use, experimentation with textiles uncommonly used for construction material in interior design, alongside fashion design methods and expertise. Discussions and negotiations occurred about how this project could be utilised in pedagogical settings to benefit the teaching curriculum, students’ learning and this research. Consequently, a plan for a potential match of interests emerged. This project took two pathways in coordination with the fashion design department: one integrated into the current curriculum through a one-week workshop; and the other was an associated semester-long design project.

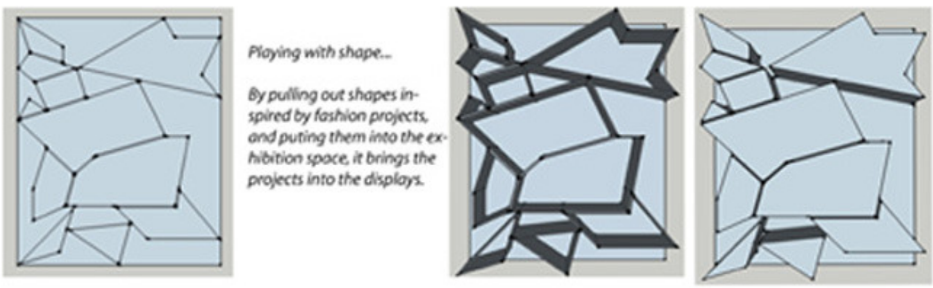
Fabricating space workshop: interior Design tutors and I discussed and developed the workshop brief open to students from fashion and interior design, advertised during the University’s Innovative Learning Week (ILW) (February 2012). The advert indicated that this workshop would lead to a longer-term project of an exhibition stand and explained the departments’ collaboration with me and my research project (see Appendix 5, Section 5.1).

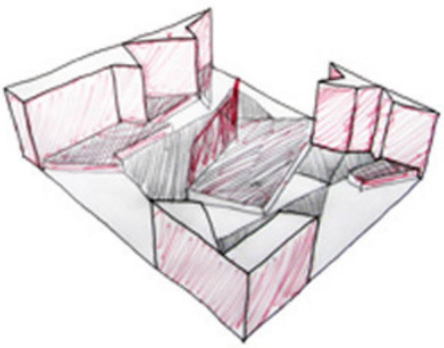
Semester design project: Third-year Interiors students typically undertake an actual project as part of the curriculum. This time, the research concept was implemented in the brief, which proposed using textiles as a building material and interweaving interior design expertise with garment design methods and insights into fabric manipulation. This occurred in collaboration with fashion students, who were available to provide guidance on textile use (see Appendix 5, Section 5.2 for the project brief).

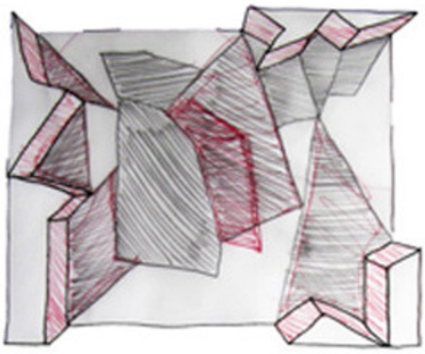
As demonstrated in Section 4.1, during the interdisciplinary ‘through’ practice strategy, I observed myself through an experiential design activity project. Likewise, in this augmenting case study, I observed other (student) designers undertaking the same design project, with the same design brief and aim to integrate the two practices of space and garment design, but following a different pathway. As discussed in Chapter 3, I was a participant observer; I also provided tutoring and consultation, mainly at the ILW workshop stage. I documented this case study through photographs, field notes and critical writing (conference papers), and conducted recorded interviews with Interiors students following the exhibition.

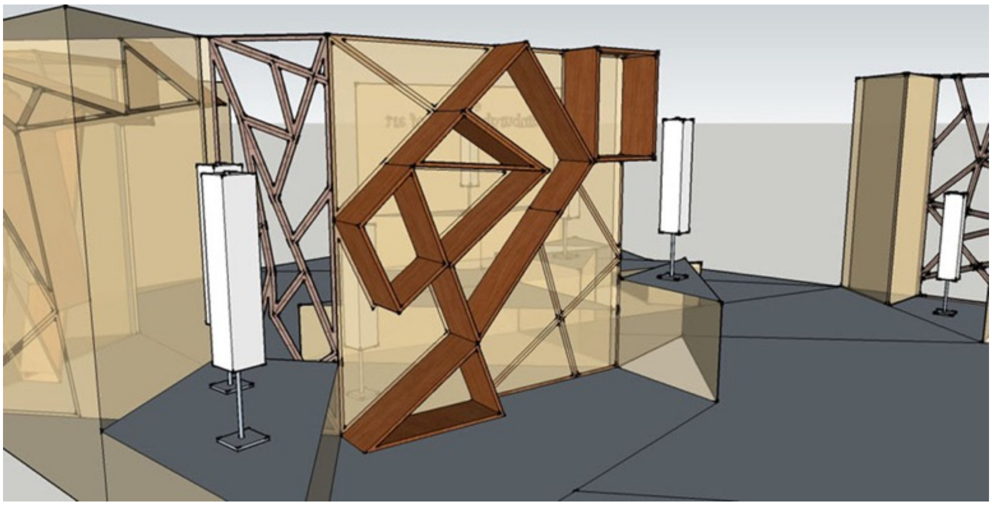
4.2.1 Design Concept Development and Presentation

Following the brief, interior design students experimented with integrating garment design expertise and principles with their current practice to explore how textiles could shape space. Eight third-year Interiors students presented their designs to the fashion students and tutors a week before the ILW workshop. In their presentations, they showed how they had started the endeavour as a semester project, and had been asked to develop individual concepts for the stand and scaled models at 1:50. At this point, they took a typical architectural approach. These students undertook their own brief research into fashion design expertise and principles, visited the fashion Design students' studio, spoke with fashion students and explored their designs. Their developed concepts varied; some students were inspired by garment shapes (Figure 4-49), tension and the visual properties of fabric (Figure 4-50), while others explored architectural approaches to constructing fabric, such as tensile fabric architecture (Figure 4-51).


Playing with shape...
By pulling out shapes in-
spired by fashion projects,
and puting them into the ex-
hibition space, it brings the
projects into the displays.

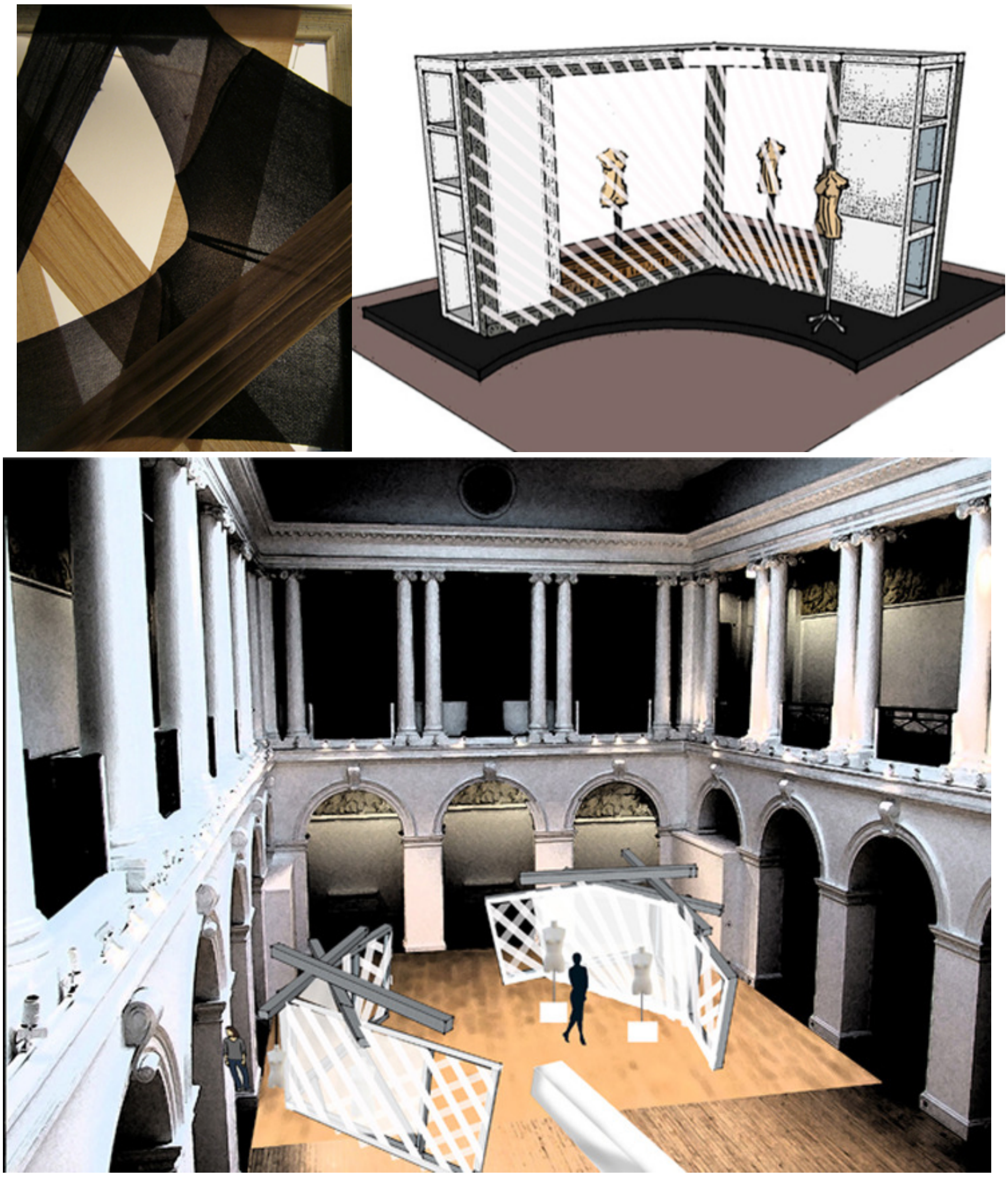






"By combining material with aluminum frames my design creates contrast. Using light and shape, I formed a space which is aesthetically pleasing and highly functional"

Figure 4-49: Third-year Interior Design students' project concept and model at scale 1:50, inspired by Fashion students' garments. Image source: Cargocollective (2012).



"Within my design process I tried to manipulate fabric using tension, to create a beautiful, but transparent canvas for the fashion departments clothing to be displayed on."

Figure 4-50: Third-year Interior Design students' project concept and model at scale 1:50, inspired by fabric's visual properties and transparency. Image source: Cargocollective (2012).

> "This design symbolizes the tent structure inside another structure. The tension made by pulling and stretching the fabric, forms patterns and shapes within it."

Figure 4-51: Third-year Interior Design students' project concept and model at scale 1:50, inspired by tensile fabric architecture. Image source: Cargocollective (2012).

4.2.2 The ILW Workshop

At the launch of the ‘Fabricating Space’ workshop, a number of these concepts were selected; groups of third-year and first-year interior design students then worked together on the selected concepts to present them using fabric models at scale 1:10.

During the week, I observed Interiors students being instructed in using a sewing machine and creating seams (Figure 4-52). They used Calico fabric for experiments (as they might in garment making), since it is an economical choice of material. They also used some sewing techniques and tools borrowed from garment making, such as pinning and stitching. Their models and concepts evolved through making, and several proposals and fabrication plans were developed at scale 1:10 by the end of the week (Figures 4-53, 4-54 and 4-55).The Interiors student groups presented their 1:10 concepts; the fashion design students then selected one concept to be developed into a full stand.

Figure 4-52: Introduction to the sewing machine for Interior Design students on day one of the ILW workshop. Image source: Author.

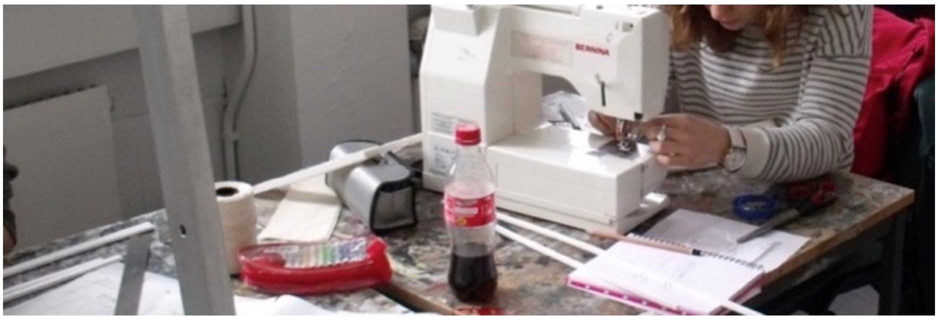


Figure 4-53: Interior Design student sewing her model at the ILW workshop. Image source: Author.

Figure 4-54: Interior Design students utilising sewing techniques (pinning) to attach and manipulate Calico on a frame at the ILW workshop. Image source: Author.

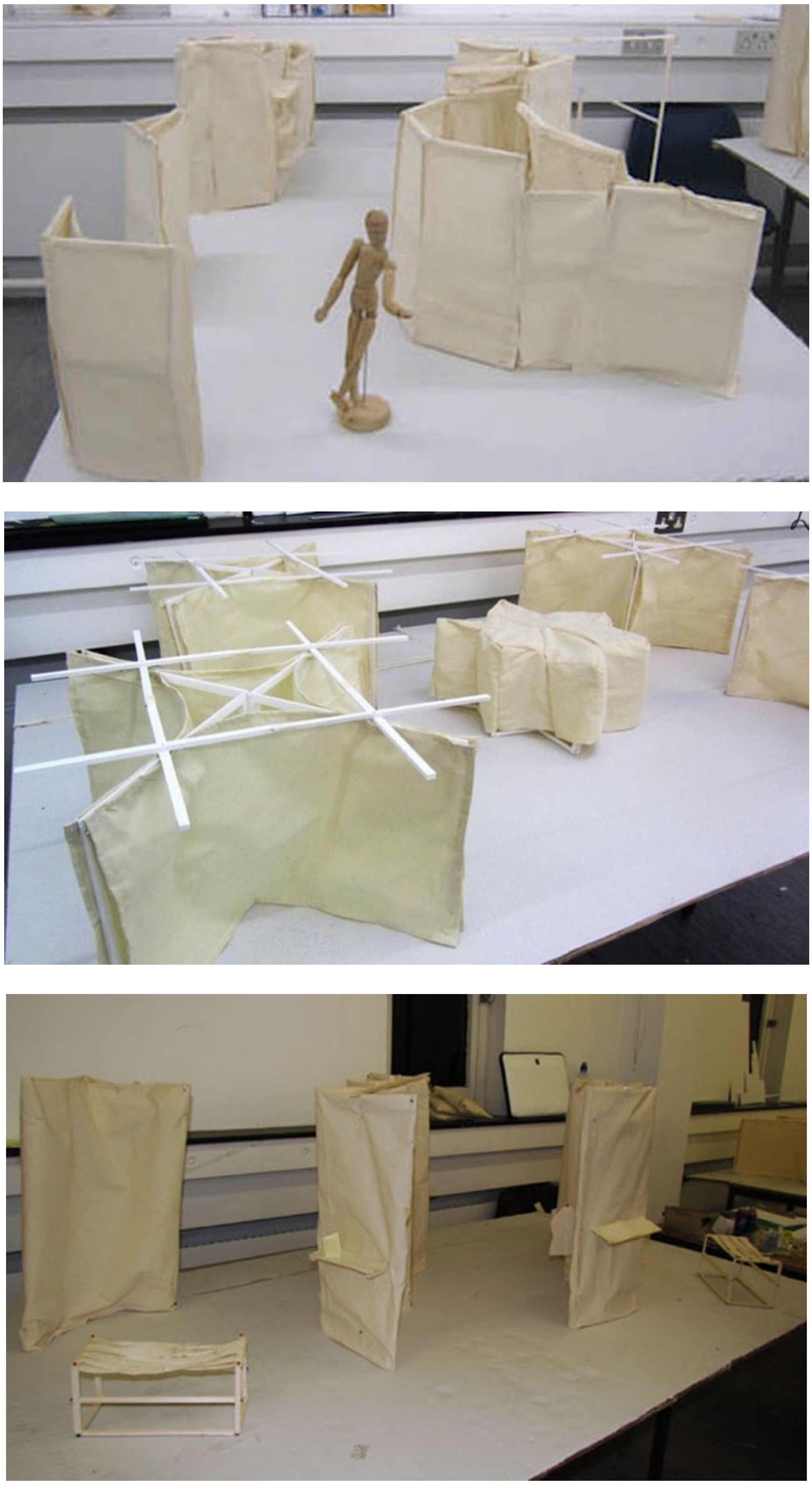


Figure 4-55: ECA stand group proposals, scale 1:10, ILW workshop. Image source: Cargocollective (2012).

4.2.3 Hands-On Investigations: The 'Toile' and Final Stands

After the workshop, the third-year students (a team of eight interior design students with various roles) completed the semester project and conducted the fabrication process. This exhibition stand was used twice: once during a third-year mid-point exhibition (Figure 4-57), and again at Graduate Fashion Week in June 2012, to display graduates' work to the public in London (Figure 4-59).

The stand's concept and design evolved between the two events, and throughout the fabrication process—similar to how a garment evolves between the first toile and the eventual garment using the final fabric. In the first event the stand was made from Calico. In the second event it used stretch net. During this process, architectural drawings became less important. Students were modifying the structure and fabric directly (Figure 4-56). This differed from their 'normal' architectural process.

Concurrently, throughout the stand's fabrication at full scale, Interiors students consulted fashion students and continued to use some fashion detailing. For instance, they used ropes and eyelets to fit and attach Calico fabric pieces to the metal frame; a detail used in corset making (Figure 4-56).

Figure 4-56: Students modifying the structure directly, and frame details of the full-scale mock-up stand. Image source: Author.

The Interiors students began the project abstractly, drawing a design concept and developing scaled models from 1:50 to 1:1. However, at later stages, they followed a garment design process, building a 1:1 mock-Calico model and refining it for a final version. They did not learn garment design and construction methods in practice before starting the design; instead, they worked in collaboration with their peers from fashion design, discussing and negotiating important concepts, such as scaled models, and experimenting directly with textiles and the aluminium frame at full scale (Figure 4-58). They also used different methods, such as patterns, rather than traditional architectural drawings, to cover the stand's seating areas.

Throughout this process, they were designing a three-dimensional sketch directly on an actual stand and at full scale. They borrowed the concept of 'toile' making and experimented directly with materials. They refined the design throughout the process of making, culminating in the eventual finishing fabrics used in the stand's final version. The Interiors students documented the whole process and created the 'Fabritecture' website for their project, *Cargocollective* (2012), (Figure 4-57).

Figure 4-57: 'Fabritecture' (mock-up stand), the third-year Interior and Fashion Design students' mid-term work. Image source: Author.

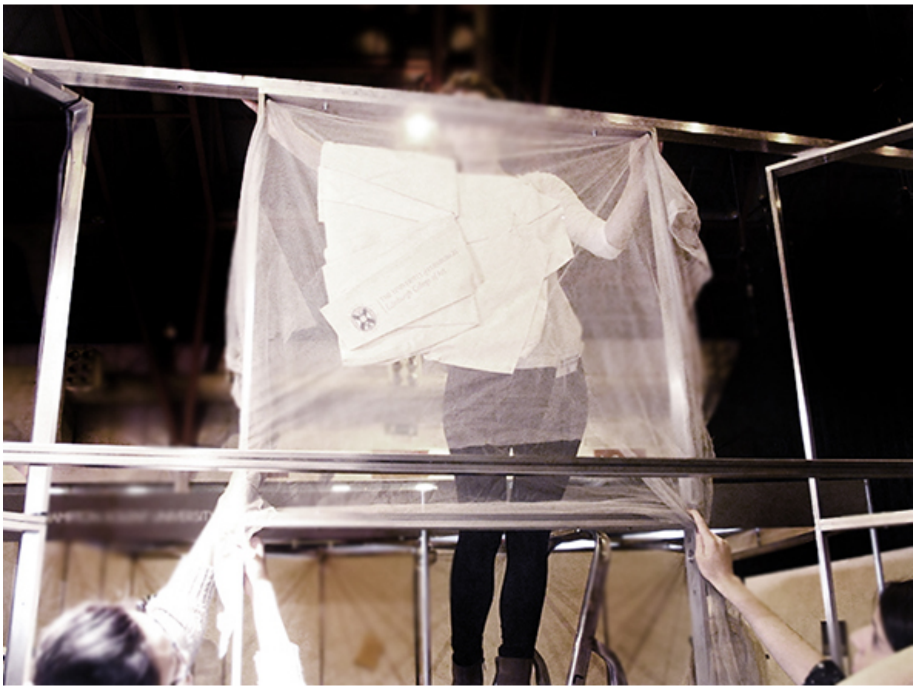


Figure 4-58: Experiments in collaboration with Fashion Design students. Top: Fashion Design students demonstrating draping directly on the metal structure. Bottom: an Interior Design student attaching textiles to the structure. Image source: Participant-1.

The second and final version, taken to Graduate Fashion Week in London, used different materials; these included panels of stretch grey net in different shades attached to the metal frame (Figure 4-59). The final stand won the Best Stand Prize for 2012.

***Figure** 4-59: The final stand at Graduate Fashion Week, London, 2012, composed of stretch grey net of different shades. Image source: Participant-2.*

4.2.4 Interviews

As discussed in Chapter 3, I conducted two interviews after finishing the project to collect reflections from the students; these occurred on 27th September, 2012 in the design studio, with lead design and lead fabrication students. They were recorded and transcribed (Appendix 5, Section 5.4), with notes taken and consent collected. Although I had some initial guiding questions, the interviews were flexible and, in this sense, semi-structured.

This was helpful for moving the conversation when a new direction of interest arose. Interview analysis is integrated into Chapter 5, which analyses, discusses and communicates this interdisciplinary research's main findings from both research strategies' pathways.

Chapter 5 Fashioning Space: Integrative Practice, Analysis, Discussion and Findings

This chapter analyses and interprets how the integration of spatial and garment design practices occurred in this research. In doing so, it traces in which aspects of practice integration occurs: in design process, methods, concepts or assumptions; how integration unfolded in practice, such as how it was triggered and initiated, developed and progressed; and under which conditions integration transpired.

To approach the above topics, this chapter identifies the analytical framework and techniques used. It highlights related knowledge types, particularly tacit and practical knowledge. It identifies the two approaches—the interdisciplinary 'through' practice strategy and the case study strategy—as two distinct pathways in which interdisciplinary understandings were achieved, and then provides an analysis of each approach. It analyses how integration materialised in each pathway. Finally, to reflect on disciplinary practice, it highlights several dialectic relationships at play in this process.

5.1 Analytical Framework and Techniques

Practice research outputs can be practical or tacit (expertise, insights, understandings) converted to explicit forms mainly by reflective narratives, models and visual comparisons. Tangible or explicit outputs involve documentation and records or fieldnotes about making and design activities, objects (actual/digital models), and visuals (2D orthographic drawings, 2D patterns, CGI 3D rendering); however, tangible outcomes embed other forms of tacit knowledge (Cross, 2006).

In this research's interdisciplinary research 'through' practice strategy, as a practitioner-researcher, I was the main instrument used to generate and aggregate data related to both tacit and explicit knowledge. Thus, self-practice provided the context for integration within my design thinking; my activity process and outcomes (including objects, insights, and understandings) were rich sources of data.

At the same time, the case study project with students provided a point of reflective comparison with my design practice. Data sources included interview scripts, notes, photographs of processes and outcomes collected from participant observation, and case documents (project brief, workshop advert, project website). Gray and Malins (2004) state that comparison and contrast is a useful intellectual analytical tool that can facilitate researchers in their attempts to "categorise, establish boundaries, find inconsistencies, discover patterns and connections, and paint the larger picture beyond the specific detail" (p.132). Comparison was a crucial analytical tool in this research, using different lenses (see Figure 5-1), including the comparison of design objects (models of different scales), media (manual/digital), assumptions (between the two disciplines), and processes (spatial design vs. garment design, collaborative vs. individual, and disciplinary vs. interdisciplinary). These comparative lenses helped me to explore different dialectic relationships between the above sides in the comparison (Figure 5-1).

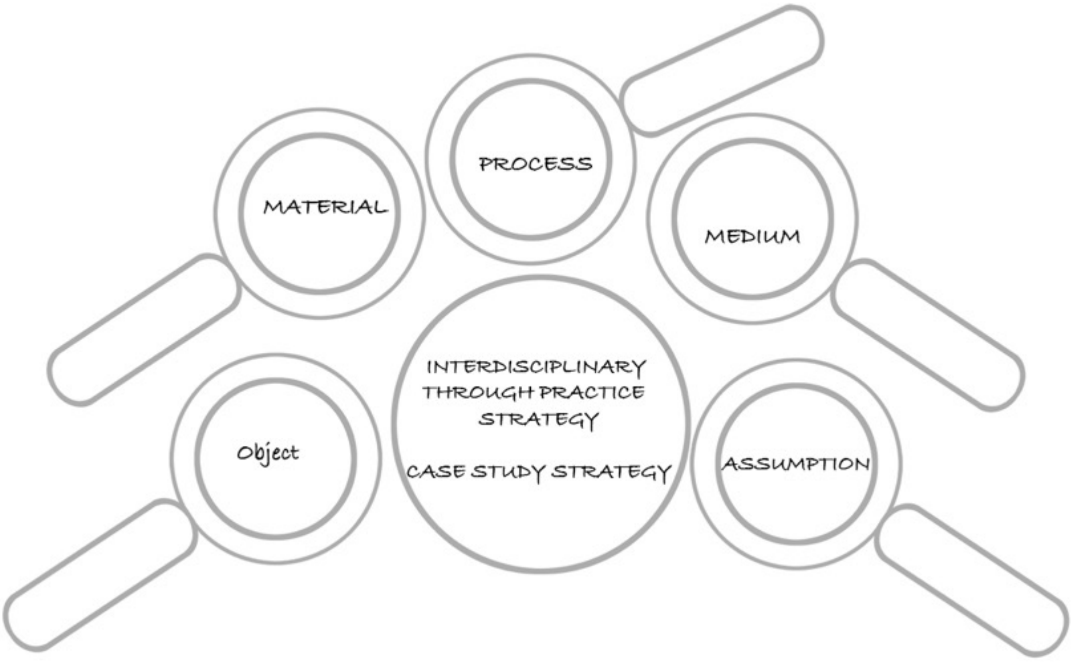


Figure 5-1: Different comparison lenses used in this analysis reflect a number of dialectic relationships, including comparing objects (models on different scales), mediums (manual, digital), assumptions (between the two disciplines), and processes (collaborative vs. individual, disciplinary vs. interdisciplinary and abstract vs. hands-on).

Niedderer (2013) states that data in practice-led research can be further examined “through analysis and evaluation using traditional methods” (p.11). Established analytical frameworks in social sciences are based on analysing explicit linguistic or textual discourses. In interdisciplinary research and research ‘through’ practice, frameworks are applied that use analytical techniques and tools related to their context.

Interdisciplinary studies involve reflective learning as a means to achieve understanding as a “cognitive and personal transformation that relies heavily on self-reflection, which promotes a stronger self-concept and greater self-knowledge” (Repko, Szostak and Buchberger, 2017, pp.100–101). The writing of an intellectual autobiography is a common method used in interdisciplinary studies to encourage self-reflection (Repko, Szostak and Buchberger, 2017).

> To accomplish this might require comparing and contrasting personal experience against existing research (Ronai, 1995, 1996), interviewing cultural members (Foster, 2006; Marvasti, 2006; Tillmann-Healy, 2001), and/or examining relevant cultural artefacts (Boylorn, 2008; Denzin, 2006) (Ellis et al., 2011, p.276).

Welch IV (2011) states that “interdisciplinarity engages in the holistic incorporation of insights from distinct perspectives” (p.34); therefore, he highlights, “interdisciplinary inquiry participates in the art of interpretation, which portends a fundamental relationship with knowledge” (p.34). Furthermore, Repko (2008) explains the “ability to think dialectically” is crucial and “is opposite [to] disciplinary thinking” (p.45). Integrative activities involve perspective-taking and holistic thinking (Repko, 2008), which “foster certain values that are guiding principles, mindsets, or attitudes” such as empathy, humility, appreciation and tolerance towards ambiguity (Repko, Szostak and Buchberger, 2017, pp.97–98).

Similarly, in research ‘through’ practice approaches, many scholars highlight the analytical role of practice (Gray and Malins, 2004; Niedderer, 2013), where reflective practice plays an analytical role. Rendell (2004, p.144) states, “in much practice-led research the process operates through generative or propositional modes producing works that may then be reflected upon, along the lines of Donald Schön’s ‘reflection in [and on] action’ (Schon, 1987)”. Gray and Malins (2004) stress the value of reflection-on-action, as a research activity where we are “telling ourselves a story about ourselves” (pp.22–23). The dynamic play between reflection-in and -on-action is present in research processes involving practice, which are “qualitative, dynamic, and reflexive (though to varying degrees)”; thus, the research process and outputs are “fluid and dynamic conceptions and interactions" (Doloughan, 2002, p.64). It is crucial, as Packer (1985) suggests, to "elucidate and make explicit our practical understanding of human actions by providing interpretations of them" (1985, p.1088 cited in Gray and Malins, 2004). Gray and Malins (2004) indicate that this notion of making explicit practical understandings and making sense of them in appropriate ways is important in art and design research.

Thus, in this research, analysis was an ongoing process. Reflection on each step led to the next. For instance, reflection on the piloting stage led to undertaking formal training in pattern cutting as a mode of investigation. Also, writing self-reflective accounts, over time, using different methods (reflective journal, peer-reviewed research papers, autobiography) was helpful to shape an overview.

It is widely accepted that art and design students have a visual cognitive style (Riding and Rayner, 1998 cited in Gray and Malins, 2004). Visualisation is an important technique in garment design, for instance. Furthermore, various forms of graphic presentation, such as drawing and diagramming, are intertwined with architectural design. Marshall and Rossman (2016) highlight the role of visuals for investigations, drawing on examples such as Leonardo da Vinci's ability to visualise due to skills in arts and visualisation (2016, p.20). Gray and Malins (2004) stress that practice plays multiple roles, including visually presenting findings in an imaginative but tangible way. Postiglione (2013) clarifies that visualisation and redrawing can "provide a way to read elements and collect data and information since they are broken down into a simpler form" (p.58). Visualisation was a main tool in this analysis to understand different stages and aspects of this research and integration process.

In this research, which uses self-reflection, visualisation, dialectic thinking, comparisons and interpretation, the analytical framework can therefore be understood as reflective, dialectic, visual, comparative and interpretive in nature.

5.2 Related Knowledge Types

One of the challenges that this research process faced was how to unearth tacit knowledge and how to externalise it and make it as explicit as possible. The challenge of elucidating the research process, data analysis and results, and making them as explicit and accessible as possible manifested itself repeatedly.

Lam (2000) states, in the context of organisational learning, that knowledge exists in different forms; articulation of these forms as an individual ('embodied') or collective ('embedded') can be either explicitly or implicitly manifest. In design research, these can occur in know-how/practical knowledge, expertise and skills, and through understandings and insights. The role of tacit knowledge is highlighted in design studies: it is traceable in the long history of tacit traditions that govern design practice (Mareis, 2012).

In this research, it was important for me, as a designer-researcher, to recognise the related epistemological dimensions and debates of tacit and experiential knowledge. Mareis (2012) explains that, since the 1980s, there have been debates concerning recognised expressions including 'design knowledge' and 'designerly ways of knowing', 'design thinking', 'sensuous knowledge', and 'experiential knowledge'. Also, concerning the rise of epistemological terms such as 'personal knowledge', 'knowledge of familiarity', 'tacit knowledge', or 'situated cognition'. She notes that, in principle, the common thing between these inconsistent terms is that "they are based on a similar concept of knowledge that is gained and applied via practical measures and that is, to a great extent, personal- and situation-oriented" (p.64).

As Niedderer (2010) highlights, "the need for justification conventionally requires knowledge to be explicit and generalisable" (p.5). Past disapproval of tacit knowledge as a crucial type of knowledge and, some of, its consequences are presented by Philpot (2012) as:

> Spontaneous and intuitive ways of working, where tacit knowledge is of profound importance, are easy to dismiss as invalid and lacking in rigour. However, such approaches used in combination with other methods open up opportunities for innovation missed when only using linear, logically rationalised working practices. (p.37)

A sole focus on explicit knowledge is being challenged by researchers, at least in art and in many design fields. For example, concerning interior design, Paterson (2018) emphasises that research is “no longer limited to the written word, this paradigm of research scholarship includes interior design as a creative process with the capacity to manifest new knowledge, innovation, and/or aesthetic refinement” (p.5).

Lam’s (2000) study of these explicit/tacit types of knowledge, despite it being in the context of organisational learning, is applicable in design. She details the differences between tacit and explicit knowledge (Table 5-1), in that explicit knowledge and related data can be easily documented by various means, such as in books. Conversely, she states, tacit knowledge, which can be personal or collective, depends on the ‘*knowing subjects’*, (a person who possesses tacit knowledge) and generally is not easily codifiable. Referring to Polanyi‘s (1962) concept that a large part of our knowledge is tacit, Lam stresses that to acquire tacit knowledge requires interaction with ‘*knowing subjects’* and engagement in practical experience in context, e.g. through learning-by-doing.

Epistemological dimensions	Knowledge type	
	tacit	explicit
Codifiability	not, generally, easily codifiable	easily codifiable
Mechanisms for transference	requires interaction with ‘knowing subjects’	abstract
Engagement with ‘knowing subjects’	dependent	independent
Acquisition and accumulation	requires engagement in practical experience (e.g. learning-by-doing), in the relevant context	through deduction in formal study
Potential for aggregation and modes of appropriation	personal and contextual; distributive; involvement and incorporation of ‘knowing subjects’ is required for recognition of its full potential	accumulated at a single location, stored in objective forms (e.g. in books)

Table 5-1: Differences between explicit and tacit knowledge. Table by author based on Lam (2000).

Crouch and Pearce (2012) illustrate that it is important for researchers, in order to extend and understand practice, to make explicit knowledge of practice. Nelson (2013) suggests that practitioner-researchers’ efforts to make tacit knowledge more explicit implies a process of “dynamic movement from the closeness of subjectivity to a greater distance, if not quite achieving objectivity as traditionally conceived” (p.20). To advance and better recognise practitioner-researchers’ tacit understanding, he recommends that methods of recognising and articulating should always be sought, despite the acknowledgment that, ultimately, it might not be possible to completely convert tacit knowledge to explicit, as propositional knowledge is expressed in writing (Nelson, 2013).

As illustrated throughout this chapter, to evoke, capture, track and then integrate and express this type of knowledge interaction with ‘knowing subjects’ through learning-by-doing was an essential source and mode of knowing and thinking in this interdisciplinary research. For instance, engaging with ‘knowing subjects’ (members of garment design practice, e.g. tutors, technicians and students) and undertaking experiential making, designing, learning, visualisation and reflection activities. Likewise, it was essential to deeply examine knowledge that resides in ‘objects’, such as artefacts, processes and ‘instructions in them’ (Cross, 2011, 2002; Niedderer, 2013), as “designers are immersed in this material culture, and draw upon it as the primary source of their thinking” (Cross, 2006, p.9). This way of knowing (designerly ways of knowing) is very meaningful for designers (Cross, 2006).

Articulating and expressing the integrated tacit knowledge achieved in this research, whether as individual or as collective knowledge, required more than a written format. So, although some of the knowledge was articulated through written narratives, there was also, for instance, visualising of the different stages and layers of this interdisciplinary research process (Figure 5-2), and the different outputs of interdisciplinary design activities in this research’s two strategies.

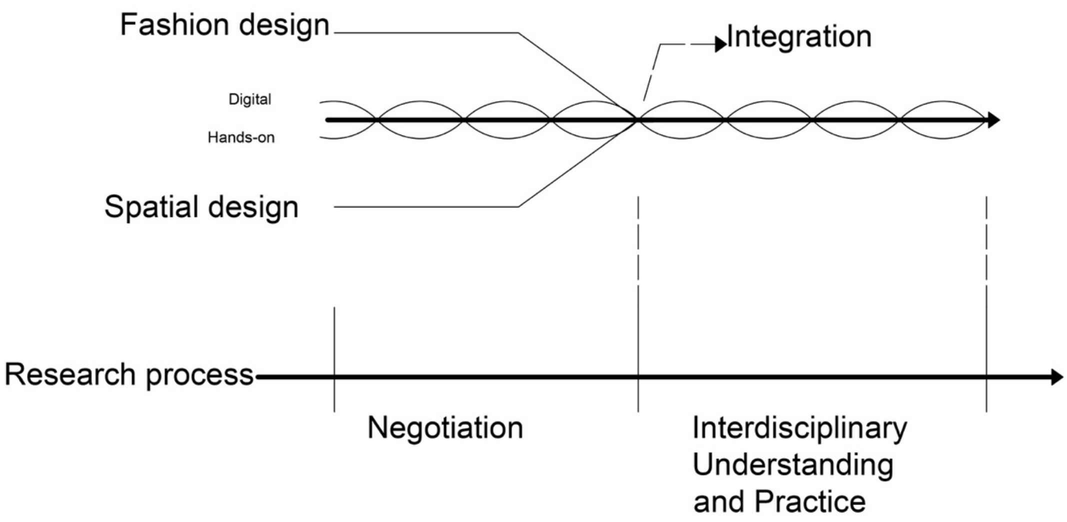


Figure 5-2: Visualisation of different stages and layers of this research process. Source: author

5.3 Achieved Interdisciplinary Insights: Two Distinct Integration Pathways

In this section I will analyse and compare two integration pathways achieved through the two strategies used in this research: interdisciplinary 'through' practice and case study pathways in which different interdisciplinary insights were realised.

Comparing the two research strategies' pathways shows that integration occurred in the design process of my interdisciplinary 'through' practice strategy pathway, analysing documentation/fieldnotes of my own design process, the generated physical and digital models and the final design (see Chapter 4, Subsection 4.1.3). Furthermore, integration occurred in my use of textiles (understanding textiles and their inherent malleability, methods of use and their underlying hidden assumptions), as will be analysed and discussed further in Subsection 5.3.1. Likewise, in the case study pathway, analysing documentation/fieldnotes of the design process and images of generated designs—eight individual design projects, three collaborative design concepts (in the ILW workshop) and the exhibition stand in its two versions: mock-up and final (Figures 5-9 and 5-10)—demonstrated an integration of the design process in the case study pathway, but no change in the use of textiles and their inherent properties, as will be analysed and discussed below (see Subsection 5.3.2).

Analysing the two processes above through comparison (Table 5-2) reveals two main points. First, interiors students had no pre-engagement with learning garment construction and textiles as a material before starting the design project. In the interiors students' pathway, although students observed garment design methods, visited the fashion design studio and viewed fashion design students' models, they did not go through experiential learning of garment design construction methods at that stage. Engagement and experiential learning directly from fashion students occurred after the initial stages of abstract design, rather than before, and were of differing intensity to the interdisciplinary 'through' practice pathway. Conversely, in my interdisciplinary 'through' practice strategy pathway, in the piloting stage, I had the opportunity to experiment with textiles and garment design methods and undertake additional formal experiential learning in a pattern cutting and garment construction course.

Second, the start of the design between the interdisciplinary 'through' practice strategy pathway and the interior design students' pathway was different. Interior design students commenced abstractly, typical of the conventional design process in architectural and spatial design. Change in the design process was remarked on later, during design development through fabrication stages, when interaction and negotiation with fashion design students occurred. Conversely, I started the design project by experimenting with actual textiles and garment design methods (a ribbed piece of Lycra, similar to the practice of garment making in direct contact with materials).

In summary, comparison between this research's two strategies/pathways shows that integration occurred within different aspects of practice. While integration of the design process happened eventually in both pathways, an interdisciplinary understanding of the potential of textiles and their inherent properties and interdisciplinary use occurred only in the interdisciplinary 'through' practice strategy.

		Augmenting case study strategy pathway	Interdisciplinary 'through' practice strategy pathway
Pre-design stage	Building an adequate level of practical knowledge in garment design	Missing	Started with building an adequate level of practical knowledge in garment design
	Hands-on experimentation with materials and methods	Missing	Playing with the material and experimenting with different methods
	Design start	Started abstractly	Started from hands-on experiments
	Integration	Integration of design process only	Integration of design process and understanding of material's inherent properties and use

Table 5-2: Comparison of process between the interdisciplinary 'through' practice strategy pathway and the case study strategy pathway. Source: author.

Investigations in this research's two pathways also highlighted conflicts in the design process between fashion or garment design and architecture or spatial design (Table 5-3) that spatial designers take for granted. Throughout the architectural process, architects design on paper, draw sketches, create models (which generally do not involve handling construction materials, but their abstraction, in card etc.), and only deal with actual materials at the building stages. In this sense, while other artists work directly with material, architects work abstractly. They draw and direct materials; they do not physically put bricks and mortar into place (Schröpfer, 2011, p.10). Similarly, in interior design, we start abstractly with architectural drawings of the plan, section, elevation, and scaled models. Conversely, in the garment-making process, some garment patterns, particularly in couture design, are constructed by draping on the dress stand. However**,** pattern cutting from blocks or adaption of existing patterns is now widely used by the dress trade because of its accuracy of sizing and the speed with which ranges can be developed. (Aldrich, 2008, p.4). Starting to make a garment involves pattern blocks, toile and grading, and methods such as draping, fabric manipulation, stitching, pleating and ribbing. Fashion designers experiment directly with materials at full scale.

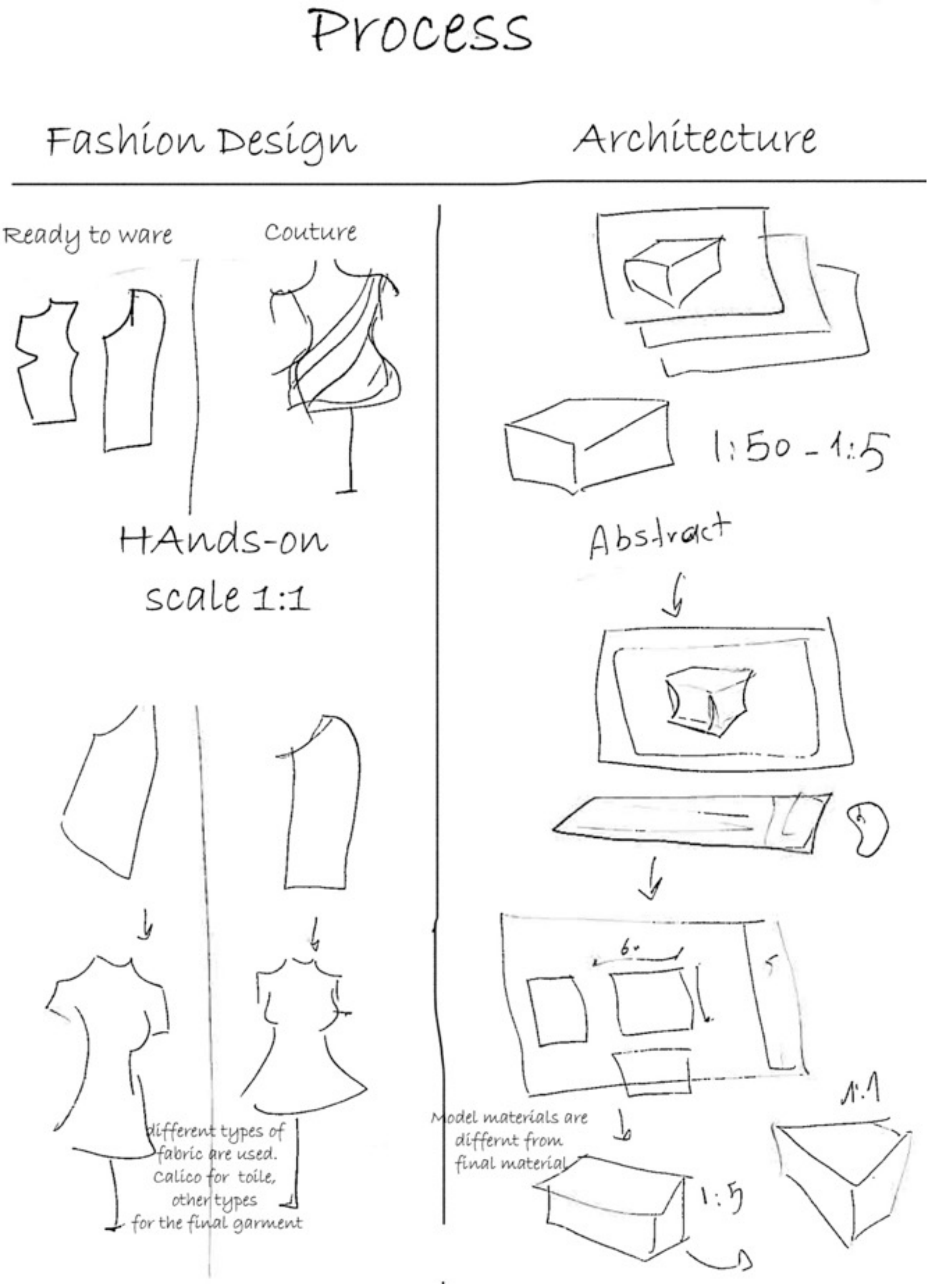


Table 5-3: The conflict in process between garment design and spatial designs. Left: garment-making design. Right: architectural/spatial design approach. Source: author.

These conflicts were revealed, reconciled and an integration occurred in both research strategies (my own ‘through’ practice and the case study). The following two subsections will discuss how these conflicts were revealed and negotiated in the two distinct pathways. Since, “if practice can change, then it is because practice is being thought of, practice is not just doing but also thinking about actions” (Crouch and Pearce, 2012).

5.3.1 Two Interdisciplinary Insights Achieved in the Interdisciplinary ‘Through’ Practice Strategy Pathway

In this strategy pathway, both an interdisciplinary design process and understanding of textiles’ flexibility and malleability were achieved.

I was a solo researcher from a spatial design background (interior architecture). However, building a level of adequate knowledge in garment making in the piloting stage enabled me to draw on the two roles of spatial and garment designer and their practices. The two came to play a key role in my creative design practice at the design project stage.

Observing and reflecting on various documentation[27] and data generated and collected from this pathway at the design project stage showed continuous negotiations between the two practices. Here, conflicts were revealed and common ground achieved. For example, starting to design with experimentation using actual textiles and garment design methods (boning) conflicts with the conventional spatial design process, which commences abstractly and follows a sequence of concept generation, drawing, making scaled models and fabricating the design at full size as a final and separate process. Rather than imagining an abstract design idea and imposing this idea on a textile, this different outset unlocked new design opportunities based on an informed understanding of fabric behaviour. Therefore, this

[27] Photographs of the process and models, digital slide presentations, reflective notes, critical writing pieces (papers), and peers’ feedback on research presentations in seminars and conferences (see Chapter 4 and Appendix 2).

design would have been impossible by abstract conceptual ‘architectural’ design processes only using manual or digital modelling tools.

A new interdisciplinary design process (Figure 5-3) was formed throughout the cyclic experience of design, making, reflection, redesign and remaking. In this unique design and fabrication activity I was reflecting-in-action; recalling my expertise whenever required, regardless of its discipline of origin. I recalled newly acquired knowledge from garment design in some cases, and, in others, recalled expertise from spatial design. For example, I recalled my expertise in interior design during the architectural process of making physical models at different scales (1:50, 1:5 and 1:1). Also, I used 3D digital modelling and visualisation software (3ds MAX 3D) to model the whole exhibition stand; I was able to explore further variations of the Single Twist space divider using this software’s ‘Bend’ and ‘Twist’ modifiers. Additionally, I adapted the ‘Unwrap UVW’ modifier, used in model texturing, to extract textile patterns required to fabricate different models.

Similarly, I used my newly acquired adequacy in pattern cutting to fix issues in digitally generated fabric patterns and to add required dart, seams allowance and important details such as pattern notches for accurate assembly. In the final stages, I used my spatial design expertise to design required joints. Ultimately, my transformed process/practice was not one of a garment designer, nor it was it one of a spatial designer, but rather, it represented the integration of both.

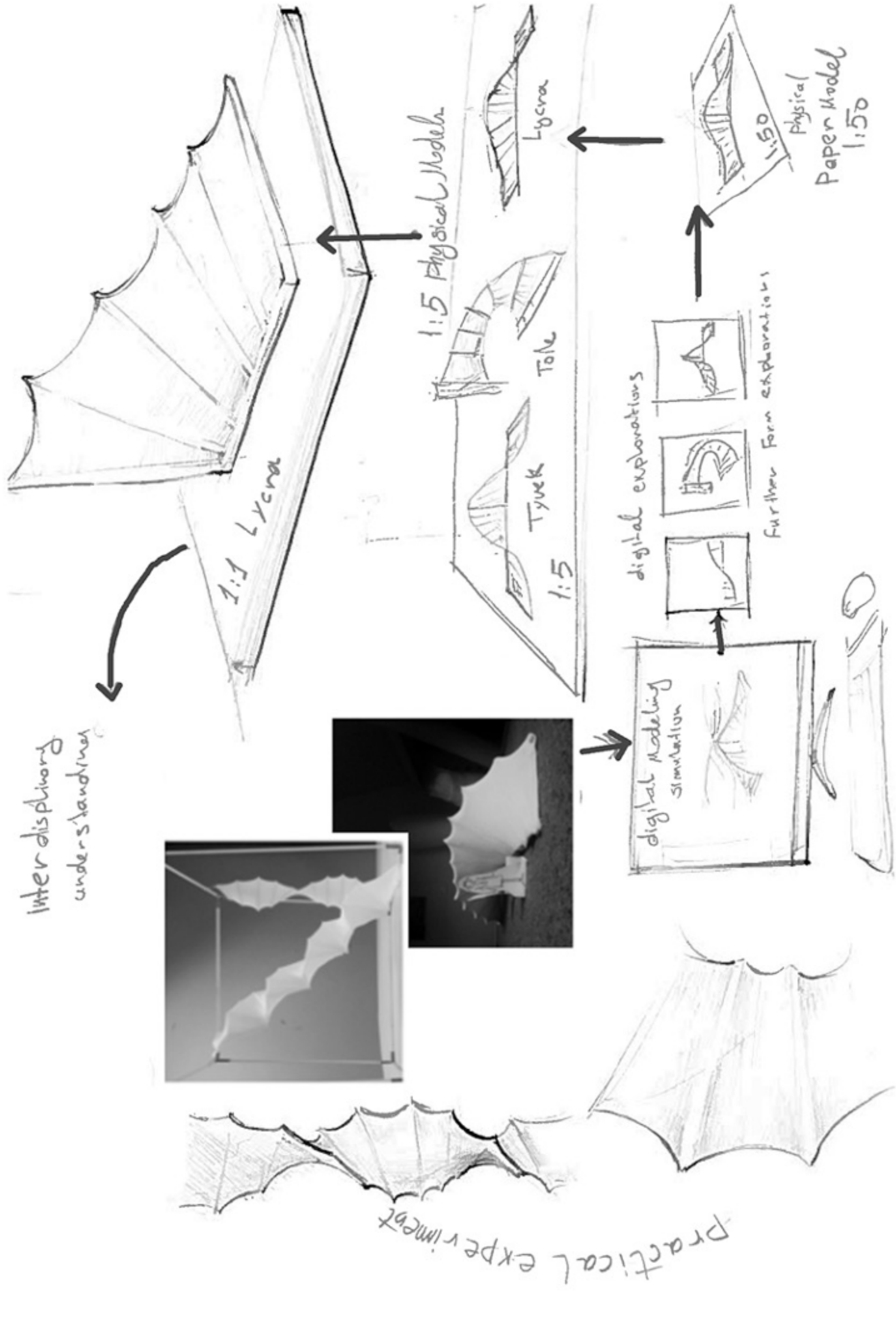


Figure 5-3: Integrated design process—summarises and illustrates the several steps using manual and digital tools of the interdisciplinary design process in the interdisciplinary 'through' practice strategy pathway. Source: author.

Furthermore, an integration of the use and understanding of the inherent malleability of textiles can be observed in the way textile was used in the exhibition stand design and models developed during the interdisciplinary 'through' practice strategy pathway (Figure 5-4 and see Chapter 4, Figures 4-40).

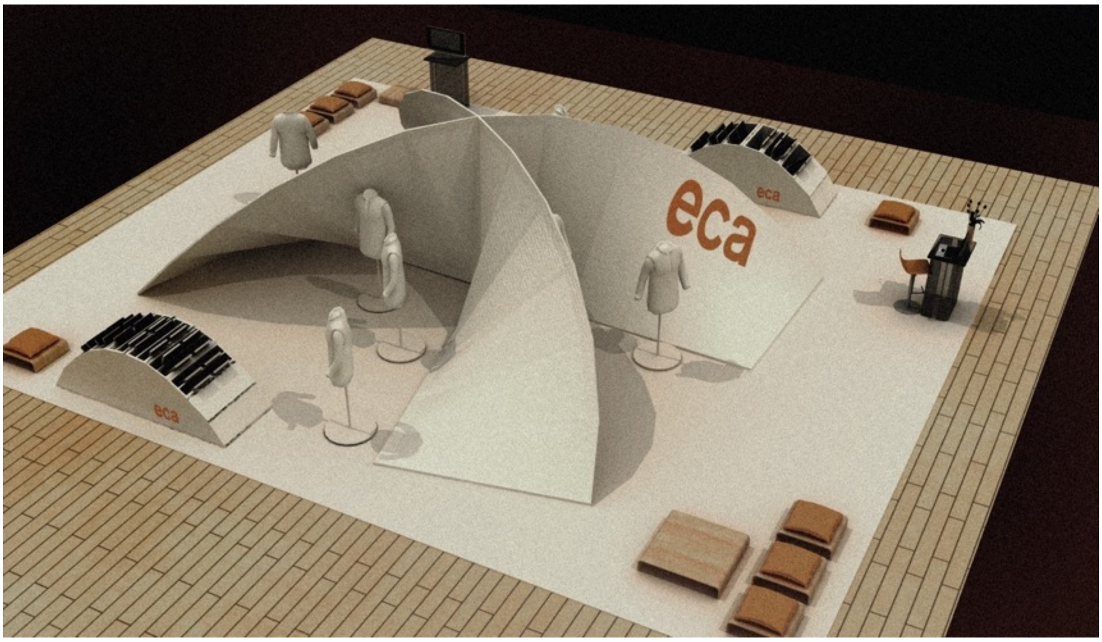


Figure 5-4: Computer-aided visualisation of the full stand. CGI source: author.

Observing written documentation/fieldnotes of my investigations in the interdisciplinary 'through' practice strategy, which contained a reflective account (autobiography[28]), showed remarkable moments that reflect a change in my attitude to, and understanding of, textile malleability. In my documentation/fieldnotes (logbook converted to a digital reflective journal), at the piloting stage, I wrote that the ability of textile to fold and drape is a very useful practical property, especially for TSI spaces, but its instability makes it difficult to build with. I even described fabric malleability as a "mixed blessing" (see digital creative journal extract, Figure 5-5).

[28] A written reflective account where I wrote about my experience in this interdisciplinary journey from one discipline to becoming an interdisciplinarian.

At this stage, despite being able to speculate about opportunities, up to a point, coming from a spatial design background, I held on to an assumption that textiles need a structure to hold them up. Thus, I was unable to find new ways to use textiles differently compared to current practices used in spatial design and construction.

- stretched cotton

Fabric properties identified in this software are:

- U bend
- V bend
- U-B curve
- V-B curve
- V stretch
- U stretch
- U compress
- V compress
- shear
- density
- damping
- plasticity

In real world textiles are malleable materials and this is a mixed blessing they are free materials but what restrict them is the gravity in first place. Wind can be considered as another factor in outdoor settings. There are natural and artificial forces affects textile surface.

Natural forces:

1- Gravity: fabric property associated with this force is weight, solution suspending fabrics or use skeletons.
2- Wind fabric property associated with this is Permeability.

Artificial forces:

1- Tension: fabric property associated with this force is bend and stretch, shear, damping, plasticity. normally fabrics are tensed with cables

Virtual forces:

In 3d max: there is two forces can be applied to fabric : gravity and local simulation, gravity force simulates the natural gravity force while local simulation is something specific to the virtual environment and doesn't exist as a force in real world. Appling this force makes garment panels simulate to the colliding object.

Figure 5-5: Describing textile malleability as a 'mixed blessing' shown in the digital reflective journal extract (notes and logbook converted into digital reflective journal).

At the design project stage, returning after an excursus into garment design to the familiar territory of spatial design, I marked a number of changes and differences in my own attitude. As highlighted in Subsection 5.3.1, I did not start to design abstractly like a typical spatial designer. Rather, I used hands-on methods to explore different spatial arrangements (space dividers); I adapted garment design methods of draping and the use of boning/ribbing, rather than using the architectural form-generating method of orthographic drawing.

An important moment for me during this process is when, in one of these experiments (see Chapter 4, Figure 4-27) I achieved a free-standing and stable design. However, this time, by *acknowledging* and *employing* fabric's ability to drape and fold under its own weight *rather than denying it,* the resulting design was an adoption of a combination between draping and boning, or what I shall call the 'Ribbed Draping' method. Achieving stability through exploiting textiles' 'unstable' behaviour (Figure 5-6) was an interesting paradox, which reflects an extended understanding of this property that goes beyond current architectural understandings of textiles' ability to fold and drape in spatial design.

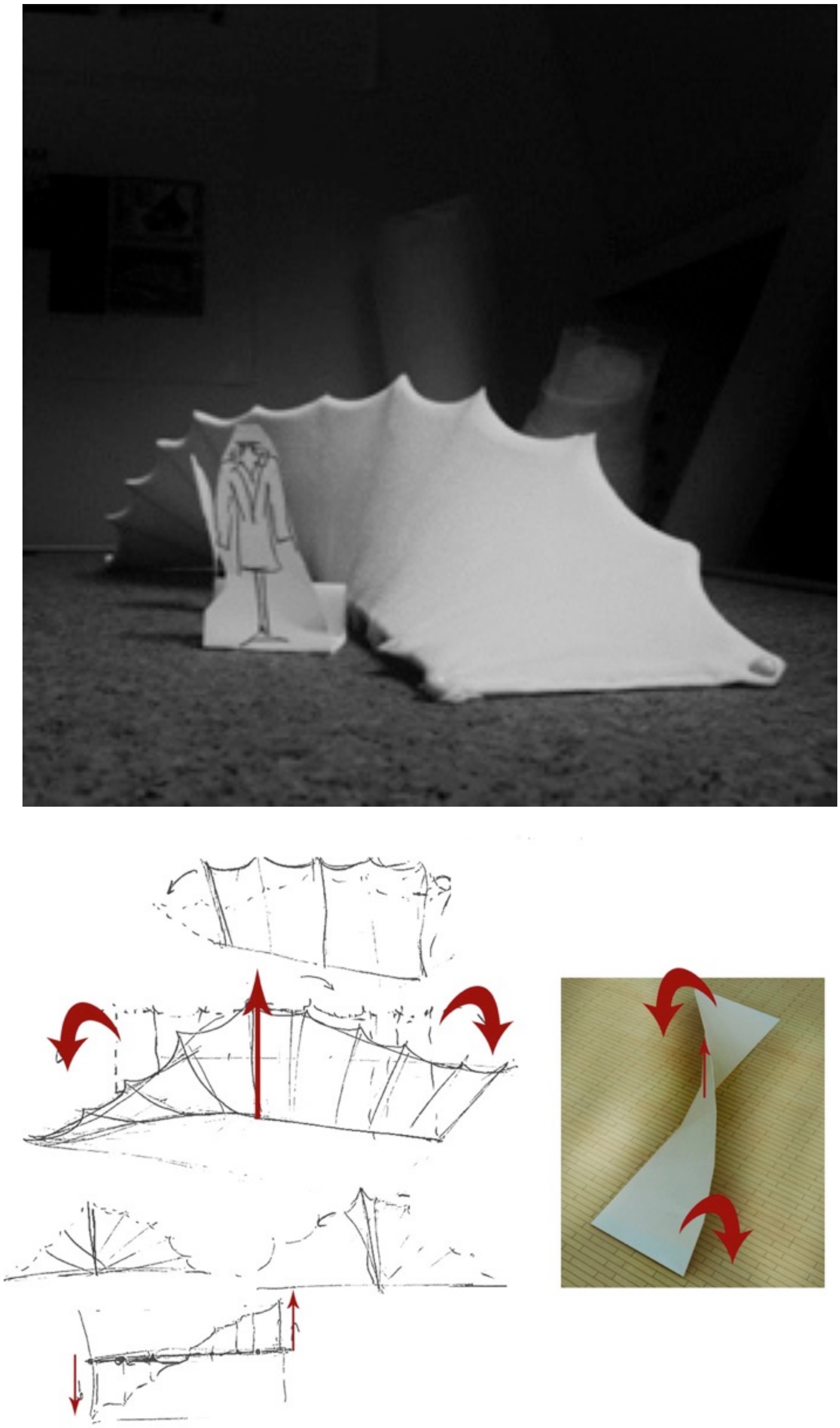


Figure 5-6: Achieving stable form using the boning/ribbing method fabric's ability to drape.

During the design project stage, an underlying conflict in the concept of stability and structural integrity was identified between spatial design and garment design. I questioned a conventional assumption commonly held in spatial design, which is that space should be stable and structurally integral, and appear so (Zevi, 1993). Similar to how the Italian architect, historian and critic Bruno Zevi (1993) criticises assumptions or 'mental inhabitation' of 'apparent solidity', which "do not depend on absolute laws of physiological gravitation, but on an inveterate habit of accepting static equilibrium of the past" (p.187). Similar mental inhabitation about fabric instability can be traced in current approaches to use textiles as a construction material (identified in Chapter 2) and in architectural discussions. For instance, architect Nigel Coates states that textile is "the antithesis of architectural support" (Coates, 2006, p.45). Also, Kalassen (2006) states that architecture maintains "typical assumptions that textiles only serve as decorative or as add-on elements separate from the conceptualisation of the hard or solid elements of architectural spaces" (p.259).

Although garments require structural integrity (Chapter 2, Section 2.4), garments must allow movement of the body. Garment design methods, such as draping and pattern manipulation, utilise textiles' malleability and the use of flexible boning (ribbing) still allows garment movement.

An investigation at this stage showed that underlying concepts about space stability and assumptions of fabric 'instability' are discipline-specific and affect textiles' use in spatial design. In this research pathway, achieving a common ground that led to an interdisciplinary understanding of textile malleability was possible by modifying the underlying concepts and assumptions from which these conflicting insights are produced, in line with Repko, Szostak and Buchberger (2017): "every discipline is based on certain assumptions that limit understanding of the subject matter and force us to look at it in a certain way" (p.233).

The space divider models achieved during this stage expressed an interdisciplinary understanding of textiles' malleability and exposed a new design possibility, which has not been explored before in spatial design.

5.3.2 One Interdisciplinary Insight Achieved in the Case Study Strategy Pathway

In this strategy pathway, interdisciplinary creative design process was achieved. But interdisciplinary understanding and use of textiles' flexibility and malleability were not achieved.

Observing and reflecting on documentation/fieldnotes of the interior design students' pathway (case study strategy) (see Chapter 4, Section 4.2) showed a remarkable change in their process. Although interior design students started their design abstractly, they moved to a more hands-on design process, similar to garment design, as their design process became interconnected with fabrication. Consequently, the importance of architectural drawings was diminished. For instance, in a conversation with Ed Hollis, the interior design students' tutor of that year, he said that "when the student arrived in London to install the final stand we realised we didn't have any drawings" (Hollis, 2012).

Analysing the two follow-up interviews conducted with the lead-design (Participant-1) and lead-fabrication (Participant-2) students to obtain their reflections on the process reveals that this change took place when fashion design students became involved and collaborated with interior design students in later stages of the design and fabrication process. Important discussions and negotiations occurred between these two groups, and several conflicts were unearthed. For instance, on the one hand, spatial design process of planning and designing abstractly and methods of scale models; and on the other hand, garment design, hands-on processes and direct experimentation with materials and at full-scale, and the method and concept of ‘toile’, which is normally at the same scale as the final garment. For instance, the interior design students referred to the first part of their project as a ‘toile’; they wrote on the stand (Figures 5-7 and 5-8) and on the project’s online page, “just like a toile for a garment, this exhibition is a three-dimensional sketch, a mock-up” (cargocollective, 2012). Fashion design students encouraged their peers from interior design to improvise; thus, to experiment directly on the aluminium structure without any previous sketches, scale models, planning or “overthinking” (Participant-2). For instance, Participant-1 described conflict in terms of concepts, methods and the process of working with fashion students: *“We [interior design students] thought, okay, why don't we see how it will look on a small scale model to stretch a little bit of fabric. They [fashion design students] said no, just make it big [at full scale], just do it.*” (Participant-1) nterior design students negotiated and sometimes “stepped back” (Participant-2) and considered fashion design students’ “way of thinking”, “outlook” or “point of view” (Participant-1 and Participant-2). Consequently, during this process the interior design students were engaged in a cycle of modifying the design of the load-bearing metal structure using actual metal pieces at full scale.

Negotiations through this later stage of design and fabrication revealed important conflicts between interior design and fashion design students’ understandings of the design process. These disagreements were largely reconciled by students modifying their underlying concepts and assumptions; eventually achieving common ground and an integrated design process or “extended thought process” (Participant-2), and, thus, a transformed spatial design process overall.

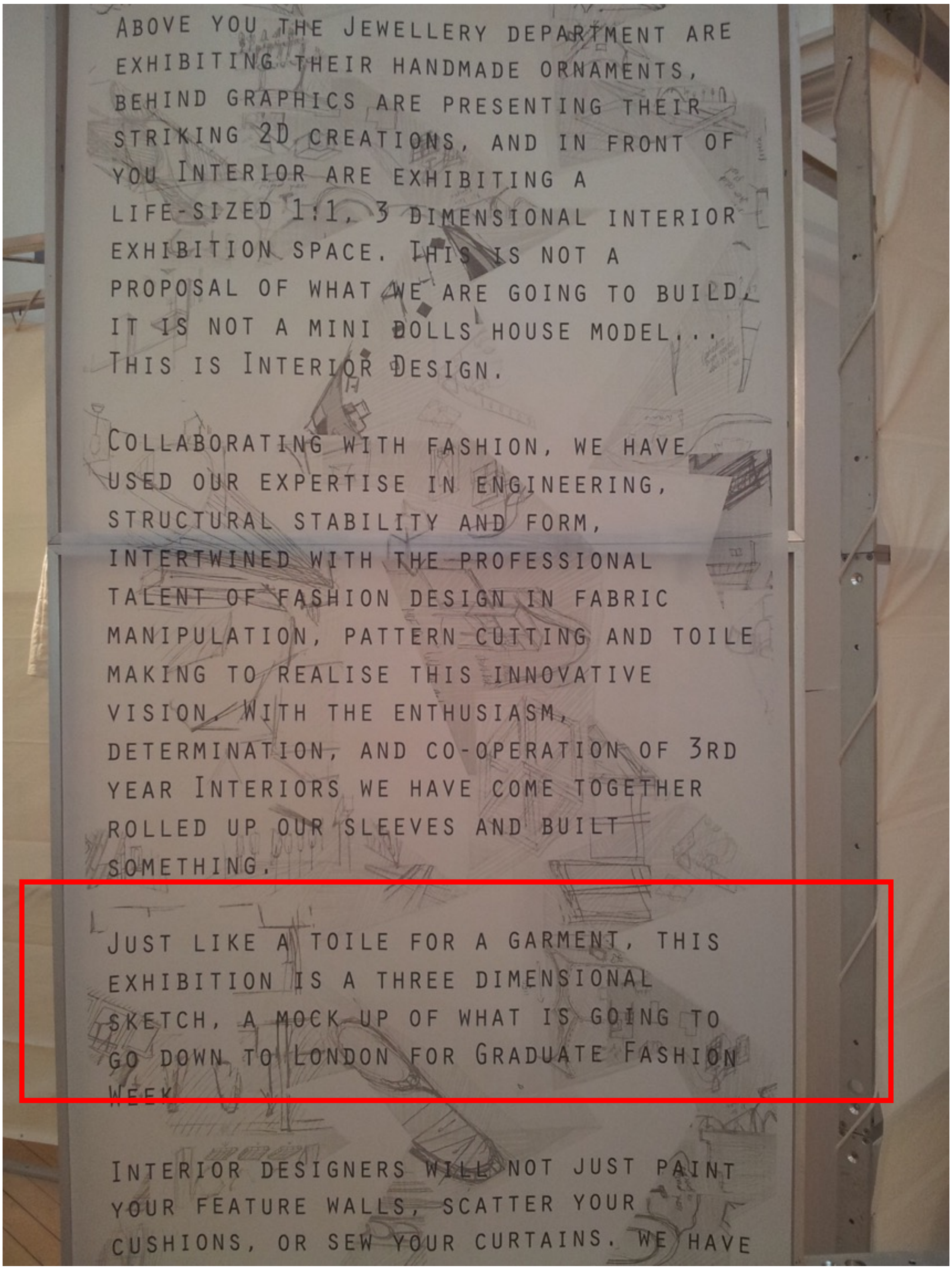


Figure 5-7: Description of the exhibition stand project first part ('toile') at Edinburgh College of Art, the Sculpture Court, 2012. Image source: author.

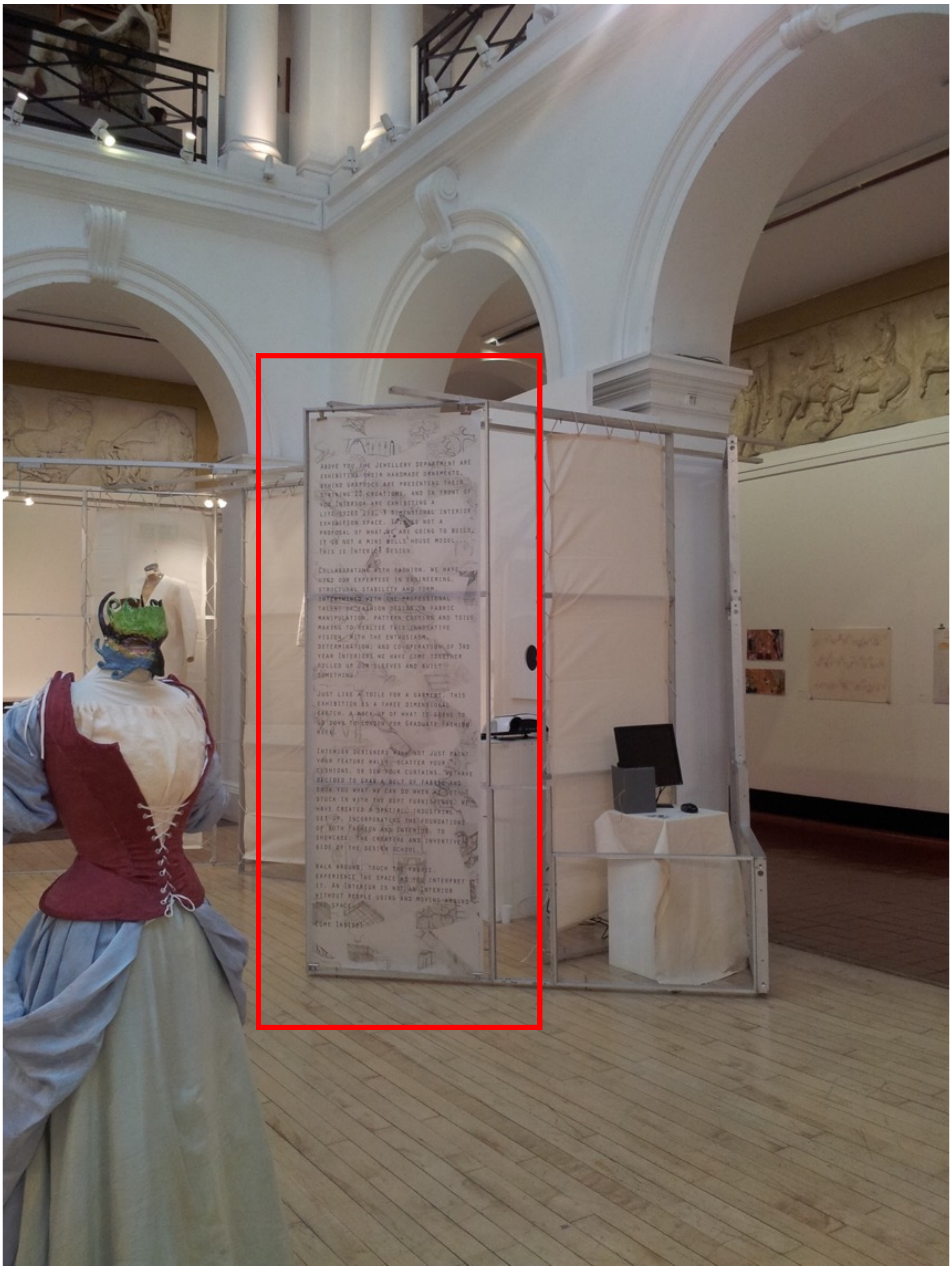


Figure 5-8: Description of the exhibition stand project first part ('toile') at Edinburgh College of Art, the Sculpture Court, 2012. Image source: author.

Although the last stages of the design project reflect an interdisciplinary understanding that interior design students achieved during the design process, designs realised by these interior design students did not reflect an integration or transformation of textile use. Rather, they reflected a continuation of traditional approaches to the spatial design use of textiles. For the exhibition stand (mock and final version), and in seven individual student projects (Figures 5-9 and 5-10), textile was attached to a load-bearing metal frame structure. In one project, textile was held in tension using masts and ropes in a tent-like structure and following tensile fabric architectural principles (see Chapter 4, Figures 4-51 and Appendix 5, Section 5.3).

Figure 5-9: Fabritecture, mock-up stand design, the Sculpture Court, Edinburgh College of Art, Edinburgh, 2012. Image source: author.

Figure 5-10: Final stand, Graduate Fashion Week, London, 2012. Image source: Participant-2.

5.3.3 How Integration Occurred in This Research's Two Strategies Pathways

This research aimed to transform practice (the use of textiles) in spatial design by achieving integration between the practices of spatial and garment design. This implied first understanding how integration may happen and may transform participants' practices (including my own) and understanding textile use and textiles' potential while doing it. As Schon (1983) notes,

> In some cases, the initial problem is framed as a problem of making […]; in some cases, it is framed as a problem of understanding […]. However, the problem is

> initially set, in the later stages of inquiry both making and understanding interests come into play. (p.312)

This section analyses how different forms of integration between garment and spatial design practice occurred in this research's two pathways, including which elements, and how integration unfolded in practice in a nuanced manner (e.g. how it was triggered/initiated, developed/progressed, in which conditions/settings/occasions).

To understand how different forms of integration occurred I reflected, holistically, on different forms of documentation, reflective accounts, and on different expressions of achieved interdisciplinary insight (interdisciplinary design processes, methods and artefacts). This required me, as an interdisciplinary researcher, to develop metacognition, which is a central interdisciplinary skill (Repko, Szostak and Buchberger, 2017). Metacognition is often described as 'thinking about your thinking', and is the awareness of one's own learning and thinking process: "it involves detaching yourself from your own worldview and attitudes as you think about how you have assembled your own thoughts about things" (Repko, Szostak and Buchberger, 2017, p.103). Consequently, this "interdisciplinary mindset takes a metacognitive step beyond subjective involvement, and in doing so attains a better vantage point for making judgments and creating knowledge—for assessing truth" (Welch IV, 2011, p.34).

I interpreted how integration happened through this interdisciplinary journey by assessing my personal experience against existing research and examining relevant artefacts (see Ellis et al., 2011, p.276). I used experiential learning theory's[29] concept of the learning cycle (Kolb, 1993; Kolb and Kolb,

[29] "Experiential learning theory (ELT) draws on the work of prominent twentieth century scholars who gave the experience a central role in their theories of human learning and development—notably John Dewey, Kurt Lewin, Jean Piaget, William James, Carl Jung, Paulo Freire, Carl Rogers and others—to develop a holistic model of the experiential learning process and a multilinear model of adult development." (Kolb, 1984 cited in Kolb and Kolb, 2005, p.194)

2005); Schon's (2008) concepts of reflection-in-action and reflection-on-action; Polanyi's (1962) concepts of tacit and practical knowledge; Repko (2008) and Repko, Szostak and Buchberger's (2017) concepts of interdisciplinary understanding as a learning process or cognitive advancement; and relevant textile-based artefacts, whether generated in this research or in previously existing garments, buildings and spaces.

5.3.3.1 Interdisciplinary Design Process, Use and Understanding of Textiles and Their Inherent Properties Within the Interdisciplinary 'Through' Practice Strategy

The following analysis elucidates that interdisciplinary understandings were achieved in this pathway; experiential learning showed itself to be the mechanism in which this integration occurred. To explain this in detail, as Repko (2008) and Repko, Szostak and Buchberger (2017) highlight, interdisciplinary understanding/insight is a learning process in which dialectic thinking[30] is essential.

Likewise, in experiential learning theory, Kolb (1984) states, "learning is a dialectic process integrating experience and concepts, observation, and action" (p.22); in that, "the process of learning requires the resolution of conflicts between the dialectally opposed modes of adoption to the world" (p.29). He defines experience as the source of learning and development. However, each individual's experiences and prior knowledge affects how learning is constructed (Gray and Malins, 2004). As Kolb (1984) states, a learner's mind is not a 'blank sheet of paper' and, instead, in experiential learning new ideas are integrated into the learner's belief system.

In this research pathway, I entered the process with a 'repertoire' of spatial design's use of textiles. When I learned garment-making insights related to textile use, these two insights were integrated. The cognitive advancement

[30] "Dialectical thinking means any systematic reasoning or argument that places side-by-side with opposing ideas for the purpose of seeking to resolve their conflict. Rather than viewing differences, tension and conflict as barriers that must be overcome, the interdisciplinary infuses these as part of the integrative process." (Repko, 2008, p.46)

(interdisciplinary understanding), as a learning process (Repko, Szostak and Buchberger, 2017), resulting from this operation is an integration between old and newly acquired knowledge (Kolb,1984).

Noting that integrating different insights into the use of textiles involves forms of knowledge beyond the explicit, reading about practice and reviewing the literature did not adjust my use or insight of textiles and their inherent properties. It was only when I started investigating ‘through’ practice that my insight started to shift and transform; thus, the role of practice was essential in initiating integration. Practice provided a context for this operation. It is important, here, to highlight the role of engagement within experiential learning in a social context, since members of the culture (garment design practitioners) facilitate the transmission of practical and tacit knowledge. Apprenticeship, for example, involves observing and uncritically imitating other practitioners or demonstrators, which conveys an important type of tacit knowledge usually missed in other forms of learning (e.g. reading, observation), and may not be obvious to the demonstrator themselves.

> To learn by example is to submit to authority. You follow your master because you trust his manner of doing things even when you cannot analyse and account in detail for its effectiveness. By watching the master and emulating his efforts in the presence of his example, the apprentice unconsciously picks up the rules of the art, including those which are not explicitly known to the master himself. These hidden rules can be assimilated only by a person who surrenders himself to that extent uncritically to the imitation of another. (Polanyi, 1962, p.55)

Representations, such as pattern blocks of a garment and orthographic drawings of spatial design, can be considered an explicit form of knowledge; however, the process of producing these drawings is largely tacit, as in the quotation above, and requires engagement in experiential learning to integrate their underlying concepts—learning the ‘hidden rules’ the master does not understand he possesses. Engagement in this mode of learning can be traced in this study within several instances at the piloting stage. I was learning directly from the pattern cutting tutor and technician (the ‘knowing subjects’) about garment manipulation methods, which allowed engagement with tacit and practical knowledge (e.g. pattern cutting, darts, gathering and corsetry), rather than looking at pattern cutting books. I was learning in an apprenticeship mode, embracing a learner attitude marked with openness, acceptance, humility and without resistance, which are also essential traits of interdisciplinary researchers (Repko, 2008 and Repko, Szostak and Buchberger, 2017). This attitude enabled me to be free from disciplinary assumptions and prejudices[31] to accommodate and accept other perspectives. It afforded me new insight about how textiles can be used and what they can do.

Furthermore, regarding social interaction with the ‘community of practice’ of garment design, being in the fashion workshop experimenting with fabric—including undertaking pattern cutting training—allowed me to experience natural social interaction with garment design tutors, technicians, undergraduate and postgraduate students as members of the garment design discipline/culture or ‘community of practice’. For example, as noted in my logbook and early versions of my digital reflective journal (see Appendix 4, Section 4.4, p.103), in discussion with the pattern cutting tutor (who saw my work in the sphere-making experiment), he recommended and demonstrated manipulating patterns of the sphere using garment techniques of darts and gathering, Also, one of the postgraduate students recommended Janet Arnold’s pattern cutting books for traditional garment patterns (see Appendix 4, Section 4.4, p.103).

Although integration began from the piloting stage and my insights started to shift, experiments of making a sleeve and a sphere were not enough to push the integration process further. These experiments were missing the

[31] Spatial design conception of the potential of textiles and their inherent properties and possible ways to direct them.

context/situation, such as the context of a spatial design project responding to a brief.

At the design project stage, returning to familiar *territory* (spatial design practice) to a *specific context* (a design project)**,** the process of integration continued and progressed where conflicts found resolutions. Research 'through' design and making was a way of thinking through action; thus, experiential learning was situated in context. Schon (1984) states that the process of designing or making can be formulated as a process of learning in which learning and reflection-in-action are inherent qualities and vehicles of design. He describes design as a "Reflective Conversation with the Situation" (p.90). Likewise, Lawson and Dorset (2009) suggest that "design itself can be seen as learning… [and] can be described as a process of going through many learning cycles (propose-experiment-learn) until you have created a solution to the design problem" (p.34). These articulations of design, as a situated learning process in continual reflection-in-action cycles, highlight design as an experiential learning process.

At this design project stage, commencing via hands-on experimentation rather than abstractly, using actual textiles and boning methods from garment design in a spatial design context allowed *dialogue between the old and the acquired to happen. New interdisciplinary insights/understanding* matured and new opportunities for textiles' use were envisioned (utilising textiles' instability to achieve stability).[32] In a process of reflection-in-action, I was improvising in the situation. As noted in Chapter 5, Subsection 5.3.1, in tandem in some moments I called on my special design skills and repertoire, and in other moments I drew on learned or newly acquired garment design

[32] I moved from attaching the space divider (draping Lycra) to the four planes of the space to develop a stable self-supported space divider based on instant feedback of material behaviour.

skills. The result was an interdisciplinary process guided by reflective practice.

Finally, this process exceeds the initially proposed ‘transference’ of methods or techniques from garment design to spatial design (see Chapter 3). This view is supported by Repko’s (2007) concept of interdisciplinary understanding as a learning process and Kolb’s (1984) concept that learning is perceived as more than the ‘mere transferring’ of information. Learning is,, instead depicted as a process where knowledge is not inactive and simply exchanged; it is ever-evolving relative to our own experiences (Kolb, 1984). This indicates that this research pathway did not capture a mere transferring of methods or techniques from garment design to spatial design. Rather, an integration of insights and the achieved interdisciplinary understanding/insight of textile use was expressed in a new interdisciplinary process, methods, and actual artefacts (space divider models and final exhibition stand designs).

5.3.3.2 Interdisciplinary Design Process Within the Case Study Strategy

The interior design students did not undertake experiential learning of garment design practice or working directly with textiles before starting their designs. However, they benefited from this experience in later stages of their project, in the workshop and the stand’s later fabrication stages. Therefore, as noted in Subsection 5.3.2, the integration of the spatial and garment design processes later occurred through their interaction with peers from fashion design. These dialogues were provoked as a result of engagement in an interdisciplinary collaborative experiential design and making activity. Experiential learning occurred when interior design students became open to learning from fashion design students. For example, in both interviews with Participant-1 (P-1), the lead-design student and Participant-2 (P-2), the lead-fabrication student, they mentioned how interior design students learned textile manipulation directly from fashion design students and how interior design students had to “step back” (P-2) and see things from fashion design students' "point of view" (P-2). This shows how these students had the attitude of a learner, considering their fashion design peers as "more experienced" (P-2) in textile manipulation. This experience transformed the interior design students' design process into an interdisciplinary one.

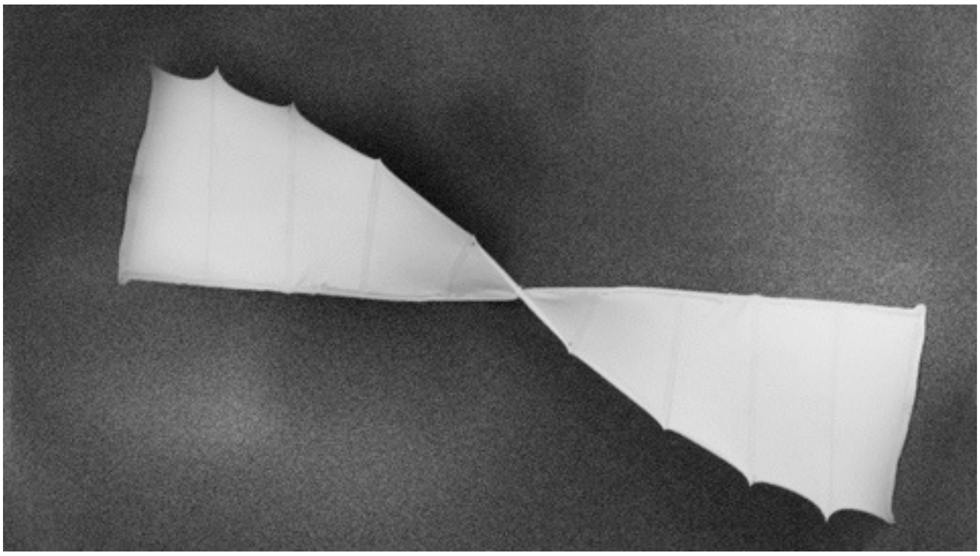
Although interior design students achieved an interdisciplinary design process, they did not have the same experience I had in the interdisciplinary 'through' practice strategy pathway (see Section 5.5) to trigger the same shift in assumptions; consequently, they were still holding negative assumptions about fabric flexibility and form stability. This was reflected in their process of design and shown in their models, where they followed the architectural approach of attaching fabric to a rigid structure. In the final collaborative exhibition design, in its two versions and in the seven individual projects, textile was attached to a rigid metal load-bearing structure and, in one project, textile was held in tension using masts and ropes in a tent-like structure and following tensile fabric architecture principles (see Chapter 4, Subsection 4.2.1, 4.2.2, 4.2.3 and Appendix 5, Subsection 5.3.1).

5.3.4 Reflection on Disciplinary Practice and Identified Dialectic Relationships

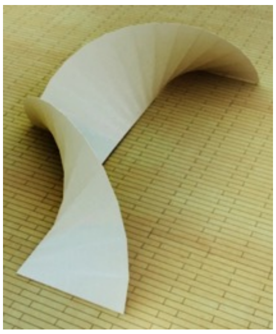
This interdisciplinary research process facilitated a reflection on disciplinary methods of spatial design, such as modelling using both digital and physical models, and the notion of scale modelling. Observing my documentation of process and contrasting physical and digital models and designs generated in the interdisciplinary 'through' practice strategy pathway showed that a number of distinct differences arose between digital models and physical models, as well as between physical models of different scales.

In comparison to physical models, digital tools facilitated a fast and a smooth, otherwise unattainable, expansion of form explorations. For instance, it would have been nearly impossible to bend the original Single Twist physical model into a circle in the same smooth and fast manner 3ds MAX made possible (Figure 5-11). Furthermore, this comparison also shows the limitation of conventional architectural sets of drawings (plane, elevations) in providing necessary fabrication data such as textile patterns to fabricate the two variations of the space divider model. Digital models' exact detailed patterns were required, rather than general dimensions.

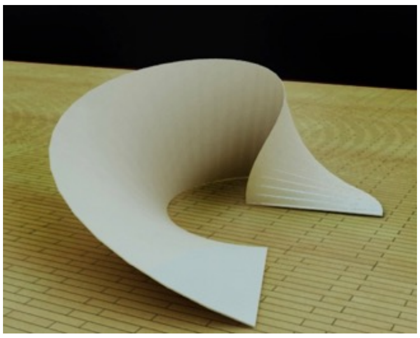
This research showed the potential of adopting digital tools (the 'Unwrap UVW' modifier normally used for character material texturing and mapping in 3ds MAX) for 'Patterning' (creating textile patterns). As digital tools were able to generate important fabrication data such as patterns, digital tools fostered my position as a fabricator; a position similar to that of a fashion designer, where I led the process from design to fabrication.



Single Twist



Double Twist



Circular Twist

Figure 5-11: Top - Single Twist physical model. Bottom - Single Twist space divider, two digital transformations, Double Twist and Circular Twist, using 'Twist' and 'Bend' modifiers.

However, this comparison revealed the limitations of digital models and 3D programmes, as they did not expose the issue of stability, real textiles' behaviour or the need for details. In contrast to digital models, physical models revealed the need for structural elements, such as joints. The differences between modelling and built work are critical and their details are an inherent part of the design process. Ludwig Mies van der Rohe notably suggested that "'God is in the detail" (Stacey, 2005). Observing and contrasting different physical models on different scales, Tables 5-4 and 5-5 show that the larger the model's scale, the more the issues of stability, details and finishing were exposed. For instance, the most remarkable difference was in the use of flexible ribs/bones (polypropylene tubes) in model scale 1:1, rather than the stiffer ones (fibreglass/wood rods) used in model scale 1:5. The flexibility of these ribs/bones made them bend, drape and follow fabric surfaces freely, which aided in distributing affecting forces (gravity and combination of bending and tension) through fabric surface and created a continuous fluent form (crease-free) (Figure 5-12). Fabric and ribs balanced each other in a natural, smooth mechanism. This can be seen and felt similar to how a garment designer drapes on the dress stand, rather than understood in numerical scientific terms. However, if required from a structural and engineering point of view, it is possible to calculate and analyse the influence of affecting forces (gravity, a combination of bending [buckling] and tension).

The effect of different materials was also observed. For instance, the combination of stretch fabric and flexible ribs in the Single Twist space divider model scale 1:1 led to a crease-free model (Tables 5-4 and 5-5). The process of building these models and each model itself provided a better understanding of these structural issues.

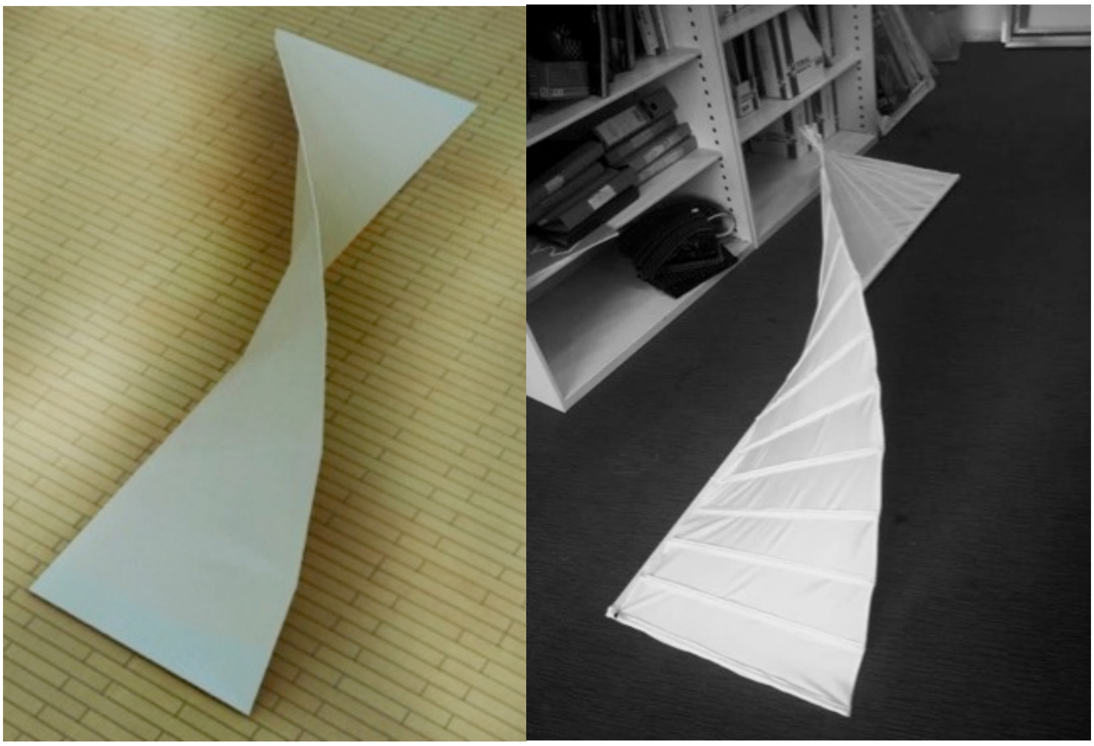


Figure 5-12: Contrast between the digital and 1:5 physical model of the Single Twist space divider in exposing issues of stability and details (joints).

	
scale 1:5	scale 1:1
-Rigid ribbing. -Fewer details. -Faceted surfaces. -Smoothness and fluidity are interrupted. -Finishing details were not required.	-Flexible boning/ribbing. -More details and finishing details were required (bullet-shape ends were required for the bones/ribs). -Surface smooth and fluid with no creasing.

Table 5-4: Comparisons between Single Twist space divider models (scale 1:5 and 1:1) show an increased need for detailed joints and finishing details in the bigger scale model.

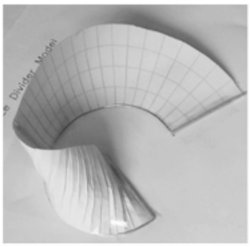
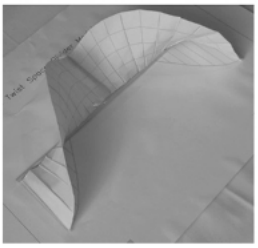
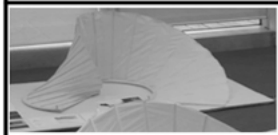
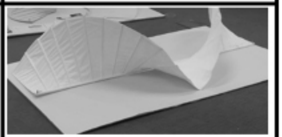
Scale	Material	Comparison between different physical models on different scales		
Scale 1:50	Paper			
		No need for joints and finishing details. No issues of stability were exposed.		
Scale 1:5	Fabric	Calico	Lycra	Tyvek
				
		Visible creasing	Difficult to sew	Visible creasing
		More details were required; the issue of stability was exposed		
Scale 1:1	Fabric	No creasing. Needed joints and finishing details. and the issue of stability was exposed.		

Table 5-5: Single Twist, Double Twist and Circular Twist space dividers. Comparison between models on different scales (1:50, 1:5 and 1:1) and materials shows contrast in exposing stability and the need for details (joints) and finishing details.

In the case study pathway, the follow-up interviews with interior design students and documentation of their design process revealed that this experience stimulated reflection on the disciplinary practice of spatial design.

As students looked at the practice of other disciplines (garment design), they became more aware of their own interior design practice. They recognised conflicts and reflected on their practice. This process revealed hidden disciplinary assumptions and tacit, taken-for-granted, design processes, concepts and methods. This experience started to shift interior design students' mindsets and they started to think differently about how to go about designing a space, including questioning their assumptions about real material behaviour and their imposed abstract design method. In comparison, a fashion design student works with their materials with constant feedback, while interior students design hypothetically. For instance, design students began to question their abstract spatial design process, which involves "overthinking" (P-2) in contrast to garment design improvisation (P-2). Or "making things hypothetically" (P-1). Plus, "ironic" (P-1) spatial design insight, which imposes narrow assumptions about materials' behaviour in comparison to how materials behave in reality (P-1). Through this questioning, interior design students became aware of the importance of details.

A holistic reflection on the above two pathways highlights a number of dialectic relationships in play in terms of shaping different interdisciplinary understandings. For example, the dialectic relationships between the disciplinary design process of garment vs. spatial design; analogue vs. digital media in spatial design; disciplinary practice vs. interdisciplinary practice; and practice vs. reflection on practice. Several lenses were used in this analysis which reflected these relationships.

5.4 Expressing and Testing the New Interdisciplinary Understanding of Textile Use

Repko (2008) states that there are several ways to express the achieved interdisciplinary understanding, including:

> …the introduction of metaphor; construction of
> narratives; the posing of new questions or the

> development of new avenues of research; the creation of a new process or physical product that is derived from the practical application of new understanding; the creation of a model (an example, pattern, archetype or a prototype that can be set before one for guidance or imitation and apply the new understanding to the problem to (1) explain the implications of the interdisciplinary understanding for an existing policy, plan, program, or schema; and (2) propose a new policy, plan, program, or schema.) (p.311).

'Fashioning Space' as an interdisciplinary way of thinking through design and textiles, and which also reflects achieved interdisciplinary understanding, was expressed in newly integrated design processes (Figure 5-3), the 'Boned Draping' method and design outcomes (exhibition stand and space divider models), as well as in writing this thesis (Figures 5-13 and 5-14).

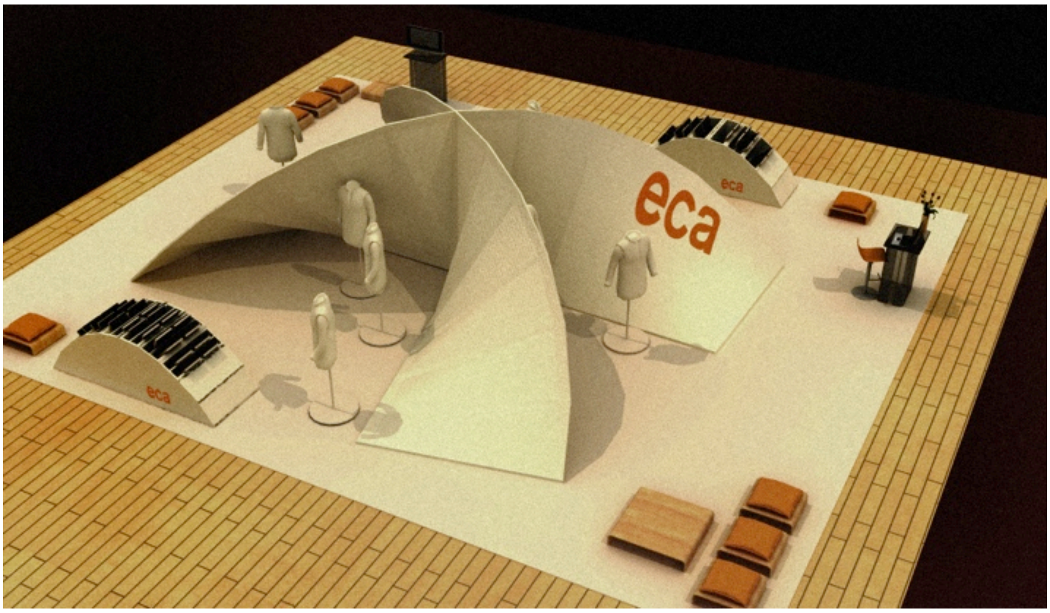


Figure 5-13: ECA exhibition stand design achieved in the interdisciplinary 'through' practice strategy, expressed an interdisciplinary understanding in an extended and transformed use of textiles' malleability.

Figure 5-14: The Double Twist space divider actual model, scale 1:1, and the 'Boned Draping' method, which employ textiles' malleability to achieve stability and express interdisciplinary understanding.

Huutoniemi et al. (2010) indicate that there are no generally agreed-upon indicators or practical guidelines to measure interdisciplinarity. However, Repko (2008) presents three general criteria—offered by interdisciplinary research practitioners—to judge whether integration has occurred: first, "when interdisciplinary understanding is achieved". Second "when the integrated result is greater than the sum of its disciplinary parts” (p. 302). Third, “when ‘a new object that belongs to no one’ is created” (p. 302). He also highlights that “the new understanding and its various expressions tests whether it is coherent, unified, and balanced, and, thus, truly interdisciplinary” (p.312). Creating a new process or product “is one way to test the new understanding and can be a stimulus of generative technologies” (Repko, 2008, p.312). If the new interdisciplinary understanding is expressed in narratives, then:

> The narrative […] should explain how [the new understanding] is, in fact, new and more comprehensive than the understandings offered by the participating disciplines or how the meaning is new compared to the meanings offered by the disciplinary insights examined. This may involve comparing the new understanding to each insight in serial fashion, insight by insight or discipline by discipline, to show how the insight, because of its narrow perspective, is unable to capture the more comprehensive nature or meaning of the new understanding. (Repko, 2008, p.312)

New understandings and their expressions resulting from this research were tested in narrative and also visually. To test the final Double Twist space divider model, as one expression of integration, I compared it against other space dividers generated following currently established approaches to build with textiles in spatial design (tensile fabric architecture, fabric stretched over a rigid skeleton and fabric suspended as curtains) (see Table 5-6).

Table 5-6 compares these dividers in terms of their design methods and principles; their three-dimensionality in space; and their use and preservation of fabric malleability. The table shows that the Double Twist was achieved by combining the use of boning/ribbing and three-dimensional draping used in garment design. Textile was allowed to hang and drape freely on rigid ribs to create a twisted shape with the support of flexible secondary ribs. The final divider spreads in three dimensions. The main insight of this design was to work with the material’s inherent malleability and properties to drape under the influence of gravity. Thus, the textile was directed in the way it naturally tends to behave, similar to how garment designers drape a garment but, in this case, draping was supported with flexible bones.

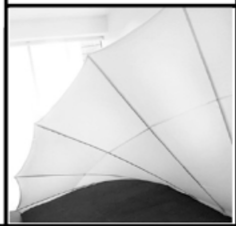
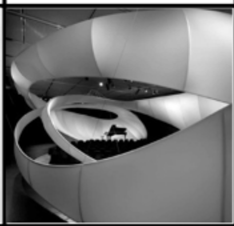
	Structure/space divider type			
	'Boned draping'	Tensile	Load-bearing frame	Suspended curtain
				
Method	Boning + Draping	Tension	Stretched over a load-bearing frame	Suspension
Dimensionality	3 Dimensional	3 Dimensional	3 Dimensional	2 Dimensional
Fabric flexibility	Maintained and utilised	Marginally maintained Not utilised	Not maintained nor utilised	Maintained not utilised

Table 5-6: Comparison between left: the 1:1 Double Twist space divider model developed in the study to other space dividers made according to conventional architectural approaches. Middle tensile space divider: right, stretched over a frame, and far-right, suspended curtains.

Furthermore, the Double Twist structure does not follow principles of tensile architecture, as applied loads in this model are different to those applied in tensile structures (there are no bending/buckling loads in a tensile structure).

Besides, it does not follow the concept of Tensegrity[33] either, which also achieves buckling-free structures, nor it is a ruled surface. This is clearly not the case in this model where flexible ribs (bones)—which can be called,, in civil engineering terms ‘cantilevers’ with partially restricted rotation—are clearly bending and curving smoothly with the flow of the fabric (Table 5-7).

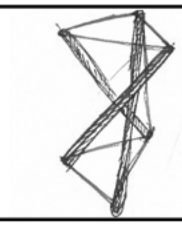
	Structural Type		
	Ruled Surfaces	Boned Draping	Tensegrity
			
Structural elements	Straight no-bending	Bending	Straight no-bending
Structural elements	Outside the surface	Integrated within the surface	Outside the surface
Surface can be flattened	Yes	No - as the darts are sewn	Yes
Bending distortion	No bending and no distortion	Bones bend and fabric stretches	No bending and no distortion

Table 5-7: Comparisons between left: Ruled Surface model, middle: 1:1, model of double twist, and right: Tensegrity model. Note that patterns cannot be flattened because of the darts beside the fabric stretches.

[33] Tensegrity (tensional integrity) was created by Buckminster fuller: “ It refers to the integrity of a stable structure balanced by continuous structural members (cables) in tension and discontinuous structural members (struts) in compression. Moreover, the cables are flexible and global components, while the struts are stiff and local components.” (Zhang, 2015, p. 1)

Also, the combined use of boning and draping in the ‘Boned Draping’ method (‘draping’ supported with boning) in the twist space divider model combines two methods that originated in garment design and differ to how ribbing (using rigid ribs) or suspending (hanged curtains) are utilised in spatial design. Table 5-8 shows the difference between suspending used in curtains in architecture, draping in garments and ‘boned draping’ in the twist space divider model.

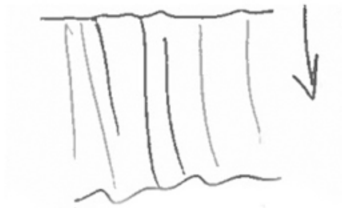
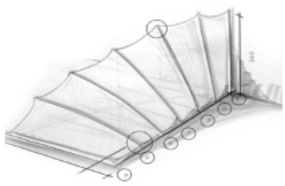
Discipline	Draping
Spatial Design	Suspended 
Garment Design	Draped on the body 
'Boned Draping'	Draped supported by bones/ribs 

Table 5-8: Comparison between draping in my model, conventional draping (suspending) in architectural curtains and draping in garments. Note that patterns cannot be flattened because of the use of darts besides the use of stretch textile.

5.5 Final Remark on Analysis

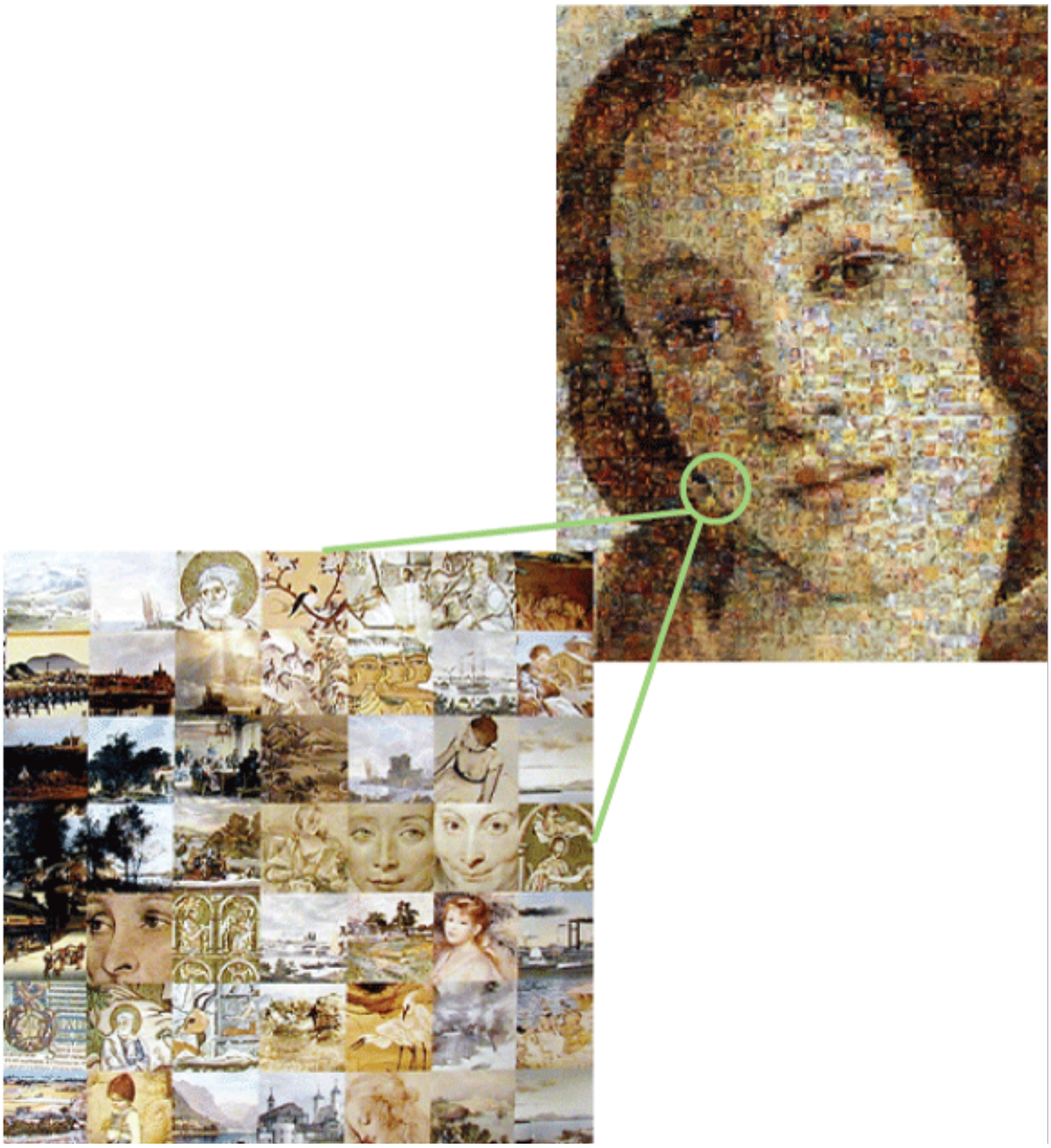


Figure 5-15: Photomosaic analogy of the research process in this interdisciplinary 'through' practice strategy through different stages of reflections. Firstly, reflection-in-action while engaged in practice at a close-up distance or micro-level (the pixel level); secondly, reflection-on-action immediately subsequent to practice (e.g. in logbooks, reflective journals, written papers and comparison with other designers' practices within the case study) at the square level (group of various images); thirdly, on completion of the research and reconsidered from a distanced position at the macro-level (a broader level, such as a composite picture of a face). Image source: Silvers (no date).

In a final remark on this analysis process, I wanted to use the Photomosaic analogy (Figure 5-15) to represent and express stages at which I analysed and reflected on my practice in the interdisciplinary 'through' practice strategy pathway—as the main research strategy.

This analysis comprised of three reflective stages at three different distances from practice. Firstly, reflection-in-action while engaged in practice at a close-up distance or micro-level (the pixel level) (see Photomosaic analogy, Figure 5-15). Secondly, reflection-on-action straight after practice—at a close distance from practice (at the group of pixels in the square level), e.g. in logbooks, reflective journals, written papers and comparison with other designers' practice at the case study. Thirdly, when I finished the research and looked back from a distanced position at the macro-level. A holistic vision/picture was shaped through examining events in zoomed-in and zoomed-out visions, possible at this final stage. At the early stages (single-pixel level), the vision was partial and some events were not deemed meaningful, and were, therefore, disregarded. For example, the importance of the piloting stage and its documentation in the integration process was disregarded; some events were omitted when converting the logbook to a digital reflective journal (see Chapter 3, Subsection 3.3.5.2). However, looking at the whole picture, at this final stage, every step (pixel) becomes meaningful and has a place in completing the whole picture of achieved interdisciplinary insight.

5.6 Summary of Analysis

This research combines analytical frameworks, tools and techniques used in interdisciplinary research and in research 'through' practice. In doing so, this research shares different forms of self-reflection, interpretation and dialectic thinking as its main analytical tools. Besides comparisons, visualisation played an important role in analysing, visualising and communicating findings.

I analysed tangible and explicit outputs of practice and these related to tacit and practical knowledge. The analysis showed that engagement in practice initiated the integration process and provided context. An interdisciplinary design process was achieved through two distinct pathways. Integration of the design process was achieved in both pathways; however, an interdisciplinary understanding of the potential of textiles and their inherent properties was achieved only in the interdisciplinary ‘through’ practice strategy pathway. In both research pathways, engagement in experiential learning of garment design practice occurred on a different timescale between the two pathways, and of differing intensity. When this engagement happened before starting the design process and in a more intensive mode, in my own practice, it facilitated a transformed understanding and use of textiles, with their inherent properties revealing new potential for textiles’ inherent malleability.

Given that interdisciplinary understanding/insight is a learning process (Repko 2008), the findings of this study show that experiential learning appears to be its activation mechanism. Engagement in experiential learning as a reflective model triggered, engaged and integrated other related tacit and practical knowledge inherent in spatial design and, more dominantly, in garment design practice. Thus, this study reveals the importance of social interactions with members of garment design practice in apprenticeship mode. This process further showed the importance of situating this integration process in context; for instance, in a design project.

Therefore, this research demonstrates that integration is not an automatic operation in both pathways. Achieving integration needs supporting occasions and conditions. Furthermore, and importantly, this operation is an integration and a transformed practice, rather than a simple transference of methods.

Reflecting on spatial design disciplinary practice, several issues were detected in the design process, methods and media. Spatial design is shown to have an overdetermined design process with fewer chances for improvisation and hypothetical treatments for material in comparison to the hands-on fashion design approach. The limitations of orthographic drawings contrasted with digital modelling and models which facilitate fast and otherwise unattainable design explorations. However digital models show limitations in exposing and solving issues of stabilities, details and finishing in comparison to physical/hands-on modelling. Intermediality of the design approach increased the benefits and reduced the limitations of both media.

Several dialectic relationships were acting in the process of achieving interdisciplinary insight or understanding. For instance, the disciplinary practices of spatial and garment design were positioned as two sides of a dialectic relationship in which integration was achieved. Furthermore, this dialectic relationship serves as a tool for reflecting on the disciplinary practice of spatial design.

Chapter 6 Research Conclusion: 'Fashioning Space': An Extended and Transformed Way of Thinking Through and About Design and Textile in Spatial Design

This chapter summarises the research process composed of 'through' practice methods, then identifies the five main research findings before proceeding to discuss the outcomes, including the limitations and implications, of the research and recommendations for future research.

6.1 Summary of the Research Process

This research aimed to expand spatial designers' outlook regarding the use of textiles in designing and fabricating Temporary Soft Interior (TSI) spaces. It involved negotiating new ways of producing knowledge associated with interdisciplinarity, using the integration of practice between spatial and garment design as a strategy and stimulus for innovation and transformation. The use of textiles as a material to design and construct TSI space or a garment provides an interface for this integration. This design research intended to imagine something different; to question and transform, rather than to describe and confirm.

However, this research's focus evolved from focusing on 'what' (outcomes of space design and method 'transference') to 'how' integration of practice occurs and may transform current spatial design practices, as well as what initiates and/or advances integration. In later analysis stages, the research started to focus on designers (including myself as a designer-researcher) and their actions (practices), with the assumption that these actions are meaningful and can be interpreted and understood (Crouch and Pearce, 2012).

Therefore, the main research questions were:

- How may integrating spatial and garment design practices transform spatial designers' use and understanding of the potential of textiles and their inherent properties in space design and fabrication?
- If integration occurs, how can it happen 'through' practice?

In this research, literature and contextual review were crucial to define the problem and related disciplines, and to build a theoretical foundation. The contextual review highlighted that research and practice across the borders of spatial and garment design have three emerging engagements (see Chapter 2, Subsection 2.5.2). However, in contrast to my research, in these engagements the use of textiles as a construction material or spatial designers' understanding of the potential of textiles and their inherent properties are not central. Furthermore, their focus is on the outcomes of integration, rather than on studying its process. Building on this contextual review, and identifying gaps in current theory and practice, I aimed to examine a different route to explore the further potential of textiles and their properties beyond their architectural context. I looked at garment design, which follows a distinct approach to constructing three-dimensional forms.

An empirical study was required to answer the above research questions, so I constructed an interdisciplinary 'through' practice research strategy and augmented this approach through a case study of other designers' practice. The 'through' practice strategy implemented concepts of reflective practice, experiential learning and designers' ways of knowing into Repko's (2008) interdisciplinary research framework. In a pilot stage, and then in a design project, this strategy encompassed reflexive design, making and learning activities using virtual and physical materials and models.

I intended to reflect on any integration that occurred during my own reflexive design practice by comparing data generated and collected from my own practice with that collected from other designers' practices. Hence, a case study strategy of the same design project conducted by other designers (design students), augmented and reflected upon this research ‘through’ practice. This case was studied through participant observation and follow-up interviews. Overall, the whole research process was not predetermined. Rather, it was open-ended, reflective and iterative.

Practice conducted in this research was within an ‘academic framework’ (Gray and Malins, 2004, see Chapter 3, Subsection 3.3.1), which means it was ‘accessible’ and ‘transferable’. My practice was documented and presented in a detailed and rigorous way in this thesis, with accompanying appendices and a Portfolio of Practice, and, thus, is ‘transferable’ in principle, even if not in particulars. The research design and the new mindset resulting from this research can be adopted by other researcher-practitioners and professional designers (see Sections 6.2 and 6.5).

This practice contained a significant element of reflection and analysis (Pedgley, 2007). To analyse this research’s practice outputs, I used self-reflection and interpretation techniques shared in interdisciplinary research and practice-led research approaches. For instance, I compared data generated and collected from the interdisciplinary ‘through’ practice strategy and the case study strategies. Dialectic thinking and visualisation also played a crucial role in analysing, communicating and visualising findings..

6.2 Summary of the Main Research Findings and Outcomes

This research’s findings can be categorised into three main categories. Some answer the initial research questions, while additional findings arose through the process. These three categories relate to an in-depth understanding of the integration process and how it transformed textiles’ use and spatial design practice; critical reflection on the disciplinary practice of spatial design; and critical reflection on the use of textiles in spatial design. This research’s outcomes include the development of Fashioning Space as an interdisciplinary way of thinking through and about design and textiles;

reflected in the development of interdisciplinary design process and interdisciplinary design method (Boned Draping method) to use textiles in spatial design, as well as Fashioning Space as a research design and TSI space framework.

6.2.1 In-Depth Understanding of the Integration Process and How it Transforms Spatial Design Practice and Textiles' Use

Findings in this section and the following two sections provide answers to two questions:

Question 1: How may interdisciplinary integration transform spatial designers' use and understanding of the potential of textiles and their inherent properties?

Chapter 5 demonstrated how different forms of integration can occur between garment and spatial design through one or more of the interconnected elements of practice: design processes, methods, concepts, and assumptions.

In the augmenting case study pathway, spatial design students' design process was transformed as a result of achieving an interdisciplinary understanding of the design process. However, a transformed use of textiles was not reflected in this instance, as the malleability of textiles remained unexploited by the students to define or structure space. Conversely, in my own interdisciplinary research 'through' practice pathway, an interdisciplinary understanding of design process, methods and the assumptions was achieved and expressed by a transformed use of textiles, exploiting their 'instability' to define and structure space.

Question 2: If integration occurs, how can it happen 'through' practice?

Experiential learning proved to be the activating mechanism for this integration. Whereas in my own 'through' practice research, engagement in experiential learning happened *before* starting the design process, and in a more intensive fashion, it facilitated a transformed understanding and use of textiles and their inherent properties, revealing new potential regarding textiles' inherent malleability in spatial design. Where engagement took place after the initial design (as happened in the augmenting case study), integration occurred less often.

This research analysed how the integration process unfolded during practice in a nuanced manner, such as how it was triggered/initiated, developed, in which conditions/occasions and the knowledge types involved. One key finding to consequently emerge is that integration begins with participants' engagement in experiential learning activities that require a learner/apprenticeship attitude marked by openness, acceptance and social interaction with members of the garment design community. Engagement in experiential learning, as a reflective model, was crucial to trigger, engage and integrate practical and tacit knowledge, which are inherent in design and textile handling processes. Progressing and developing an integration process requires a situation (e.g. a design project) for it to arise.

The above finding highlights the limitation of reading about practice, as it fails to engage all forms of knowledge that practice can produce. For instance, the contextual review in Chapter 2 suggested differences in how garment designers handle and manipulate fabric compared to architects, such as scale differences between garments and spaces, and the absence or presence of a human body as structural support. These differences appeared as though they might be an obstacle to achieve integration. However, the course of practice proved this initial assumption to be prejudiced and discipline-specific.

This research demonstrates that integration is not an automatic operation when bringing two disciplinary practices together. Achieving integration required supporting occasions and conditions. It also demonstrates that ‘transferring’ or adding certain elements/methods from one practice to another is not an accurate articulation of this overall process. A new approach or understanding brought from one disciplinary practice to another integrates with current practices or understandings, rather than cleanly and clinically adding to these. This integration forms a cognitive advancement, or what is called an ‘interdisciplinary understanding’, which can be expressed in a transformed practice (interdisciplinary process, methods, and actual final designs).

This research reveals that several dialectic relationships act to achieve interdisciplinary insight/understanding. For instance, the disciplinary practices of spatial and garment design are positioned as two sides of a dialectic relationship between which integration is achieved. This dialectic relationship serves as a tool for reflecting on the disciplinary practice of spatial design.

6.2.2 Critical Reflection on the Disciplinary Practice of Spatial Design

This integration process facilitated critical reflection on spatial design and revealed several tacit disciplinary concepts and processes.

Spatial design is shown to have a determined design process with fewer opportunities for improvisation in comparison to the garment design process. Spatial design implies hypothetical treatments for material in comparison to a hands-on fashion design approach. Orthographic drawings demonstrated limitations in fabricating TSI spaces. The findings in Chapter 5 suggest that digital spatial design modelling and texturing tools can be adapted to solve the challenge of finding textile patterns required for fabrication.

While digital modelling and models facilitate fast and otherwise unattainable design explorations in spatial design, limitations arise in exposing and solving issues of stability, detailing and finishing in comparison to physical/hands-on modelling. Therefore, I suggest that ‘intermediality’ in the design process can increase the benefits and reduce the limitations of both media.

Additionally, it was observed that representations, such as pattern blocks for a garment and orthographic drawings of spatial design, are an explicit form of knowledge. However, the process of producing these drawings is largely tacit and requires engagement in experiential learning to integrate the concepts underlying their creation.

6.2.3 Critical Reflections on the Use and Understanding of the Potential of Textiles and Their Inherent Malleability in Spatial Design

Textiles' inherent ability to drape and fold is perceived and used differently between garment and space design. It is avoided in most architectural solutions, while it is celebrated in garment making. The new interdisciplinary understanding achieved in this research reveals that textiles' ability to drape and fold can be employed to achieve structural stability. This is in line with theories of interdisciplinarity, which highlight that disciplines dictate what we know and what we can do with this knowledge (Repko, 2008). This research finds that how spatial designers' constructed disciplinary understanding and assumptions about textiles, and their potential, dictates and governs how they use them. Concurrently, disciplinary traditions including design media—which we also take for granted—play an important role in determining the whole design process, its methods and outcomes—for instance, starting the design abstractly or in a hands-on fashion using digital or hands-on methods all are significant in the design process and outcomes.

6.2.4 Fashioning Space: Research Outcomes

Lyall et al. (2011) state that the outcomes of well-conducted interdisciplinary research can result in "new academic disciplines or sub-disciplines, new insights, shortcuts and solutions to intractable problems and better decision-making" (p.18). With that in mind, the main contribution of this research is the development of 'Fashioning Space' as an interdisciplinary way of thinking through and about design and textiles. This new way of thinking reflects an *extended* and *transformed insight*/*understanding* of the potential of textiles and their inherent properties in spatial design. This new insight is revealed in the *integrated* design process and method developed in this research. Significantly, this research offers a solution for the paradoxical relationship between textile malleability and spatial stability, and, notably, developed a new ‘Boned Draping’ method to use textiles to define and structure space.

The ‘Boned Draping’ method enable designers to achieve a free-standing and stable design by acknowledging and employing fabric’s ability to drape and fold under its own weight, rather than denying it. As demonstrated in Chapter 5, Section 5.3.1, this method reflects an extended understanding that goes beyond current architectural understandings of textiles’ ability to fold and drape in spatial design. This method challenges the underlying concepts about space stability and assumptions of fabric ‘instability’ that affect textiles’ use in spatial design. It expresses an interdisciplinary understanding of textiles’ malleability and exposes a new, unprecedented design possibility, which has not been explored before in spatial design.

The Boned Draping method, found in this research investigation, is demonstrated in achieving a self-supported space divider in its three variations (Figure 5-11). In principle, this method is based on attaching malleable textile surface to three primary solid perpendicular ribs (straight or curved ribs) and then allowing the textile surface to drape under its own weight, supported by secondary flexible ribs. The flexible ribs allow and support the textile surface to drape and spread fluently and smoothly. The resulting designs do not rely on the enveloping space structure to achieve stability or balance, since they are self-supported. Further, resulting designs do not necessarily rely on symmetry to achieve balance, as shown in the circular Single Twist space divider (Figure 5-11). This research investigation showed that employing digital tools is effective and essential to realise further variations of designs achieved following this method. Therefore, further research, which combines hands-on and digital investigations, is vital to further develop this method and to extend its use, for instance, to exterior settings, where forces such as wind, rain and humidity can be taken into consideration.

Furthermore, the development of ‘Fashioning Space’ as a research design, to conduct interdisciplinary ‘through’ practice research, marked by openness and flexibility, and characterised by being interdisciplinary, pluralistic, naturalistic and experiential, builds on various dialectic relationships between tacit and explicit knowledge; theory and practice; action and reflection-on-action; digital and analogue; abstract and hands-on; garment and spatial design; disciplinary and interdisciplinary thinking.

Finally, this research has developed TSI as a framework to frame research investigations about interior spaces that are temporary and soft (made out of textiles) (see Chapter 1, Section 1.5 and Chapter 2, Section 2.1). This framework created an interface between spatial design, textiles’ inherent properties and garment design. The shared use of textiles between the two different artefacts (TSI space and sculptural garment) provided a shared phenomenon between the parallel approaches of spatial and garment design practices. This led to the development of the ‘generative metaphor’ of ‘TSI space as a sculptural garment’, which helped to frame the research problem and presented the essence of TSI space as being flexible/malleable, foldable, structural and transportable. This metaphor is generative, as “it generated new perceptions, explanations and inventions” (Schön, 1993, p.142). I used the TSI framework and the associated metaphor as a tool to analyse, reflect, understand and question our current understanding of the use of textiles and their inherent properties in spatial design and construction beyond their current architectural origins. Further research can be devoted to further applications of forming the TSI framework or comparable frameworks in other design disciplines and beyond (see further research in Section 6.4).

6.3 Recognising the Challenges and the Limitations of the Current Study

Challenges inherent in interdisciplinary research and the multidisciplinary nature of spatial design (see Chapter 1, Section 1.5) imply a further challenge in positioning the research and myself as a researcher. Many authors, in the literature of architecture, interiors and design research, highlight the multidisciplinary, inherent nature of design (Cazeaux, 2008; Koo, 2012; Nelson, 2013; Lucas, 2016; Rowe, 1987; Sarvimaki, 2018; Schon, 1980; Simpson et al., 2010; Wang and Groat, 2013). Wang and Groat (2013) state that architecture and most design and professional fields involve broad “multidisciplinary qualities and research questions which exceed the scope of a single epistemological framework” (p.27). Likewise, while this research contributes to the context of many fields, positioning it in a closed and specific position has been, nonetheless, challenging. Positioning myself as an interior architect/designer within this interdisciplinary research implied an open-ended position which, in turn, meant that links to garment design, textiles, architecture, art, structural engineering and other relevant fields can be anticipated on different levels and in different areas. Cross (2019) expresses this challenge thus:

> This, it seems to me, is the challenge for design research—to help construct a way of conversing about design that is at the same time both interdisciplinary and disciplined. We do not want conversations that fail to connect across disciplines, that fail to reach common understanding, and that fail to create new knowledge and perceptions of design. It is the paradoxical task of creating an interdisciplinary discipline. (p.A5)

Related to this, constructing interdisciplinary research in the context of research ‘through’ practice was challenging, especially as general models for conducting interdisciplinary research, such as Repko (2008), are not directed to the context of research involving practice in art and design.

Furthermore, despite the careful efforts to utilise several elucidation techniques and methods to articulate tacit knowledge associated with this research, the limitations of a full conversion has to be acknowledged.

This research showed experiential learning to be the mechanism of integration. I pursued intersubjective[34] views in my interpretation, and assessed my personal knowledge against participants' (interior design students) point of view, and against current literature and knowledge about experiential learning and interdisciplinary thinking as a process of learning. However, my findings show that the topic is complex, and has multiple tangential, interdisciplinary issues attached to it, where deep knowledge of the psychology of learning, which I lacked, might consolidate this research further, or suggest further dimensions and insights. For that reason, this research constitutes a base for future interdisciplinary research, including other areas of knowledge, such as sociology and psychology.

It has to be noted that such research output is context-bound because it deals with the use of textiles in spatial design and a focus on TSI spaces (temporary, interior and constructed from textiles). Also, the analysis in this research is limited to research through my design practice and a case study of other designers' practice (interior design students)—a possible limitation of working with design students rather than design professionals is discussed thoroughly in Chapter 3. Although this research draws attention to what can be learned from a limited number of cases, the analysis is limited in terms of generalisability. However it can be transferred—in principle, if not in its particulars. This study needs to be understood as foundational to future research into the wide scope of integrated spatial and garment design practices.

[34] Traditional qualitative research assume that (a) knowledge is not objective Truth but is produced intersubjectivity" (Marshall, and Rossman,2016, p. 22). By exposing research to peer academics feedback on many occasions, such as conference papers, presentations, and seminars. At the same time, undertaking a case study of other designers' practice and comparisons to own practice helped to develop intersubjective views.

6.4 Research Implications and Recommendations for Further Research

This research has implications for practice and textile use in spatial design, which can be extended to other design disciplines and materials. It will appeal to designers and researchers interested in re-examining and extending their use of textiles' inherent properties beyond disciplinary boundaries. It presents an example and a model of interdisciplinary 'through' practice research between spatial and garment design. It has the potential to be exemplified and extended to achieve integration in a reversed direction or between similar design disciplines.

This research has implications for design education. This is because it examines and emphasises the importance of providing interdisciplinary practice opportunities in design education, and provides strategies to develop the interior design curriculum in this direction. Furthermore, it triggers provocative questions and opportunities to link design research, practice, learning and education.

This research reveals and elucidates many aspects related to tacit and practical knowledge in garment and spatial design practices, which can be utilised in the development of digital design and fabrication software and technologies of garment making, as well as spatial design.

Further research resulting from this study has a wide scope of influence:

<u>The integration of garment and spatial design digital tools:</u> This research, initially, aimed to integrate digital tools of garment and spatial design practices. However, the course of practice showed that such research requires foundational study based on experiential engagement with materials. Building on this research, as a foundation, it may be possible to study the integration of garment and spatial design digital tools; for instance, CLO 3D fashion design software or Marvelous Designer with those of spatial design such as 3ds MAX.

Further study on the mechanism of integration: this study demonstrated that experiential learning was the mechanism for integration. This research recommends further study on the mechanism of integration and to involve social dynamics from social science and psychology perspectives. Also, further research is recommended on the impact of disciplinary education and constructed understandings of design practice and material use.

Related to interdisciplinary integration, future research is suggested to develop an interdisciplinary design toolkit to be utilised/implemented in both professional practice and design education and beyond. This implies distilling the main steps, procedures and required conditions to achieve interdisciplinary integration of practice. For instance, building an adequate level of knowledge in relevant fields by adopting an apprenticeship (open) mode of learning and engagement in experiential learning in context and situation. Concurrently, to develop required interdisciplinary thinking/mindset, for instance, suggesting ways to develop a range of interdisciplinary skills and traits, such as the courage to explore unfamiliar territories, flexibility and perspective-taking. This toolkit can have a wide application in other design specialisms, in art and beyond. Application can include disciplines in which tacit knowledge and experiential learning play a vital role, for instance, teaching, nursing, organisational learning and science; for example, current directions for integrating network engineering and programming/coding in computer science.

Assessing the benefits of linking interdisciplinary research through design and materials to design education: creating valuable learning opportunities by linking research projects to curriculum development is not an uncommon practice, and its positive impact was evident in this collaboration. Such efforts and collaborations create valuable opportunities for joining research and education communities in collective and social learning similar to Wagner's concept of 'communities of practice' (Wagner, 1998).

Further research is recommended to further applications of the TSI as the framework developed in this research (see Section 6.2.4). Developing the TSI framework assesses transforming spatial designers' thinking and approach to space design, and the potential of textiles and their inherent properties beyond current conventional architectural approaches. A similar process can be applied not only to other design disciplines, but also to art and beyond. This implies defining a framework in which an interface between two—or more— disciplines can be identified. This interface could be a tangible or intangible material, a procedure or a process. By examining how this interface is approached differently between involved disciplines, new understandings and insights may be unearthed.

Concerning TSI space, this research recognises these spaces as a subset of interior spaces and argues for further historical study, characterisation and identification of TSI space which can be designed by spatial designers, artists and, further, by garment designers, using their expertise. This is similar to how textile architecture is defined as a subset of architecture and soft sculpture as a subset of art based on the use of textiles as their main construction material.

6.5 'Fashioning Space': A New Contribution to Knowledge

The contribution of this research is to the field of interdisciplinary research, as well as presenting an empirical study of how an interdisciplinary research framework can be applied to the context of research 'through' practice. Creating, through interdisciplinarity, a new connection between research and practice beyond current established approaches, this thesis also demonstrates how design, as a way of thinking through material, can be positioned within the design research context. Furthermore, it shows how design, as continual cycles of experiential learning and reflection-in-action, can be a strategy to achieve integration of practices.

This research achieved interdisciplinary integration between spatial and garment design. However, it did not focus only on integration outcomes, but develops an in-depth understanding of how integration may happen—especially because the current literature shows a paucity of research outputs focused on the integration process. This thesis indicates that achieving integration is not automatic and is not a mere transferring of methods when bringing two disciplinary practices together. Also, that the conditions in which integration is achieved are those of being situated in context (e.g. in a design project) and building an adequate level of practical knowledge through experiential learning (of textile handling) involving interaction with members of the community of practice. Furthermore, this thesis demonstrates that experiential learning is the activating mechanism for achieving integration.

This research provokes critical reflection on the practice of spatial design in terms of process, concepts, design methods, media and, most importantly, the understanding and use of textiles. It provides a transformed and extended spatial design understanding and use of the potential of textiles and their malleability in spatial design. It provides a solution for the paradoxical relationship between textiles' malleability and space's stability. Additionally, this research highlights and promotes interdisciplinarity as a valuable device and exercise to facilitate a critical examination of disciplinary education for interior design students.

This research develops and presents 'Fashioning Space' as an extended and transformed way of thinking about the use of textiles in spatial design practice beyond disciplinary boundaries and prepares the ground for further research into the rich territory of integrated garment and spatial design practices.

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